

Summary of Field Quality Data in D3L102

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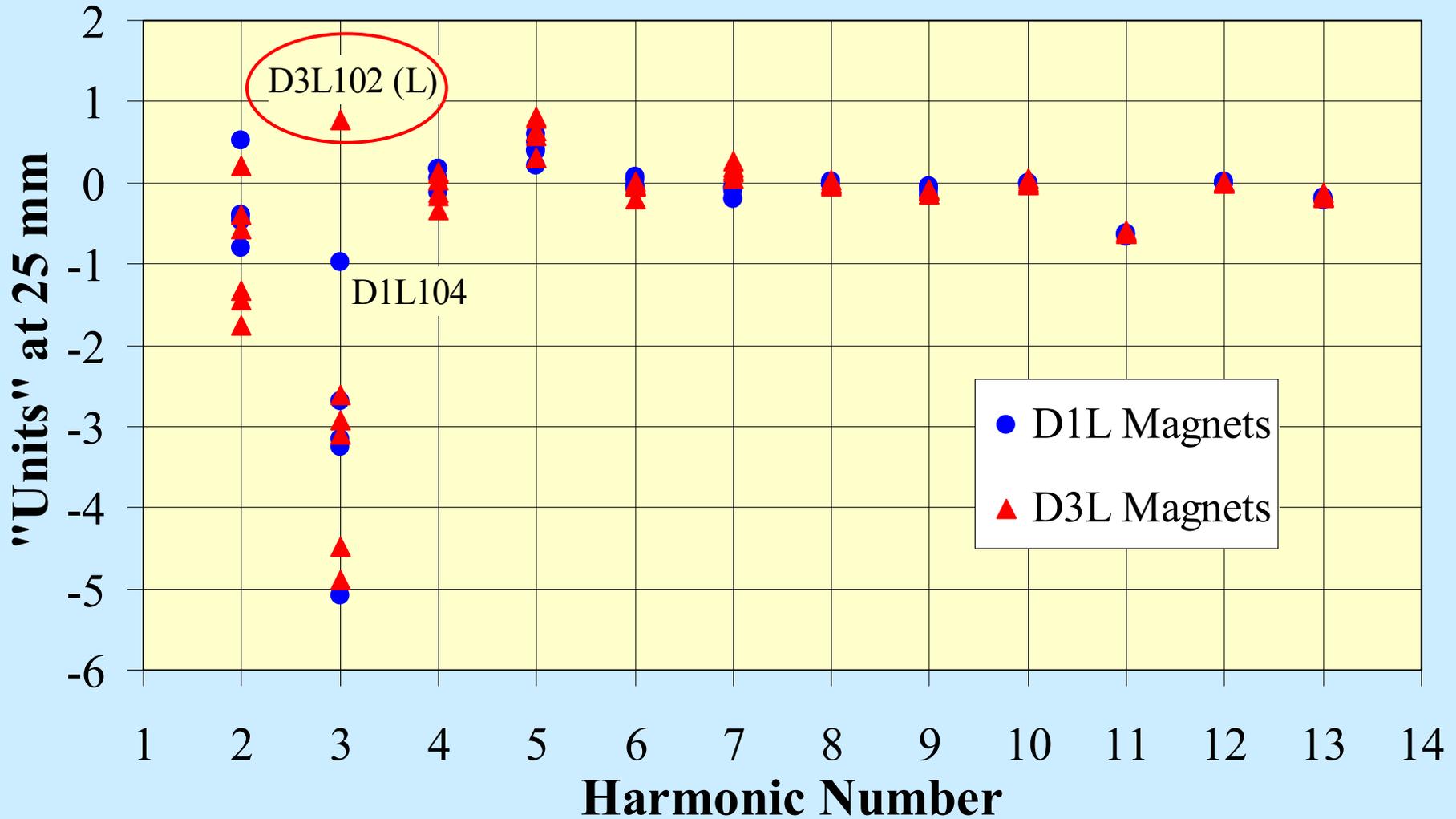
Brookhaven National Laboratory, Upton, NY 11973

D3L102 Field Quality Acceptance, BNL, June 30, 2005

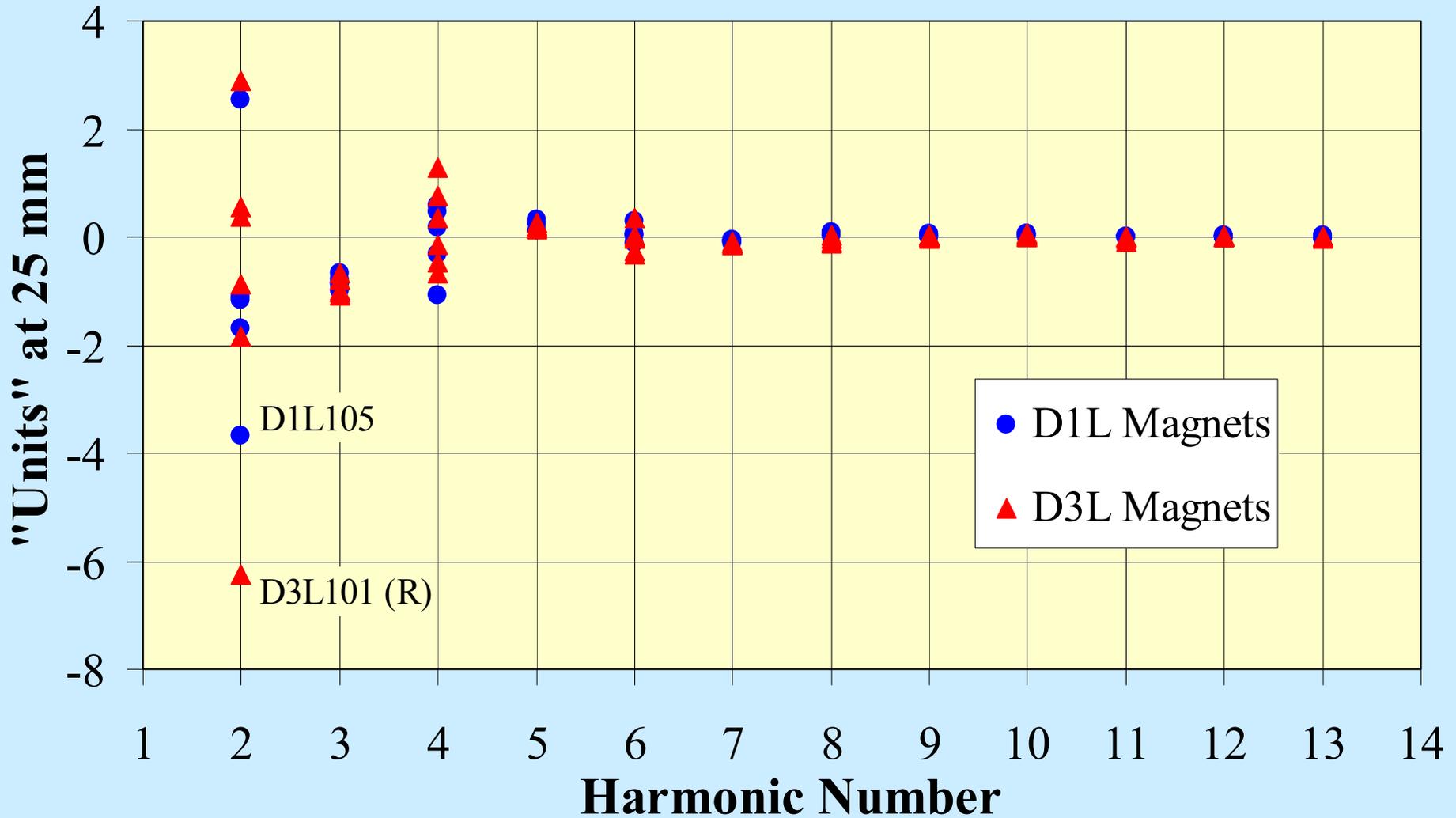
Warm Measurements

- Warm measurements have been completed in all the three D3 dipoles, using a 1 meter long mole at 10 axial locations in each aperture.
- Field angle is measured relative to gravity. Systematic error in calibration is removed by measuring field angles from both ends.
- Fiducials are surveyed on the test stand. Survey and field angle data are combined as per agreement with CERN regarding coordinate transformations.
- Integral transfer function is measured with a non-rotating, 10-meter long coil.
- **All warm measurements are done *before* cold test. (All the D1's were measured *after* cold test– T.F. diff.)**
- The *warm harmonics* in D3 are consistent with the D1 dipoles. (The cold harmonics differ due to cross-talk.)

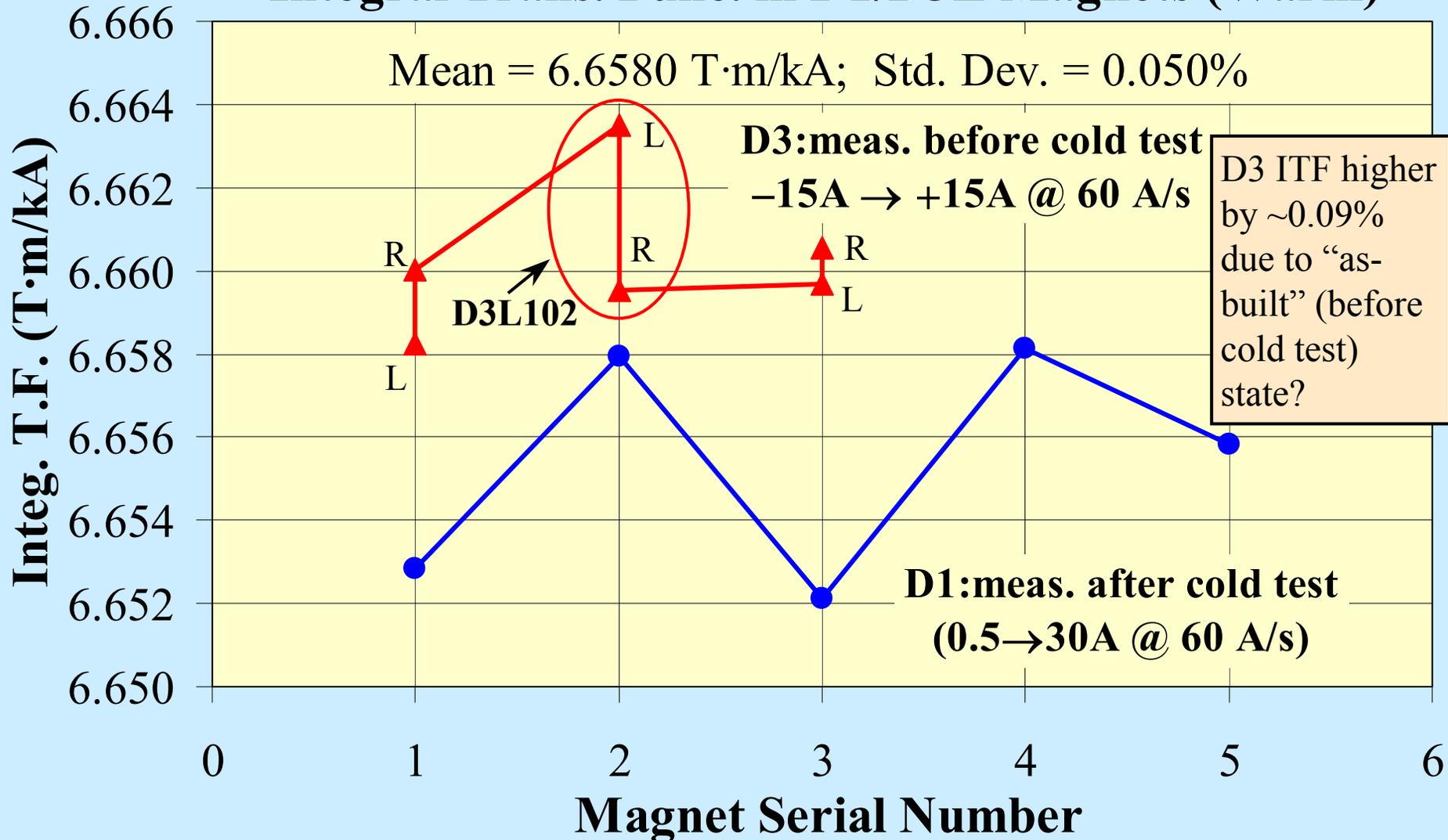
Int. Normal Harmonics in D1/D3 Magnets (Warm)



Int. Skew Harmonics in D1/D3 Magnets (Warm)

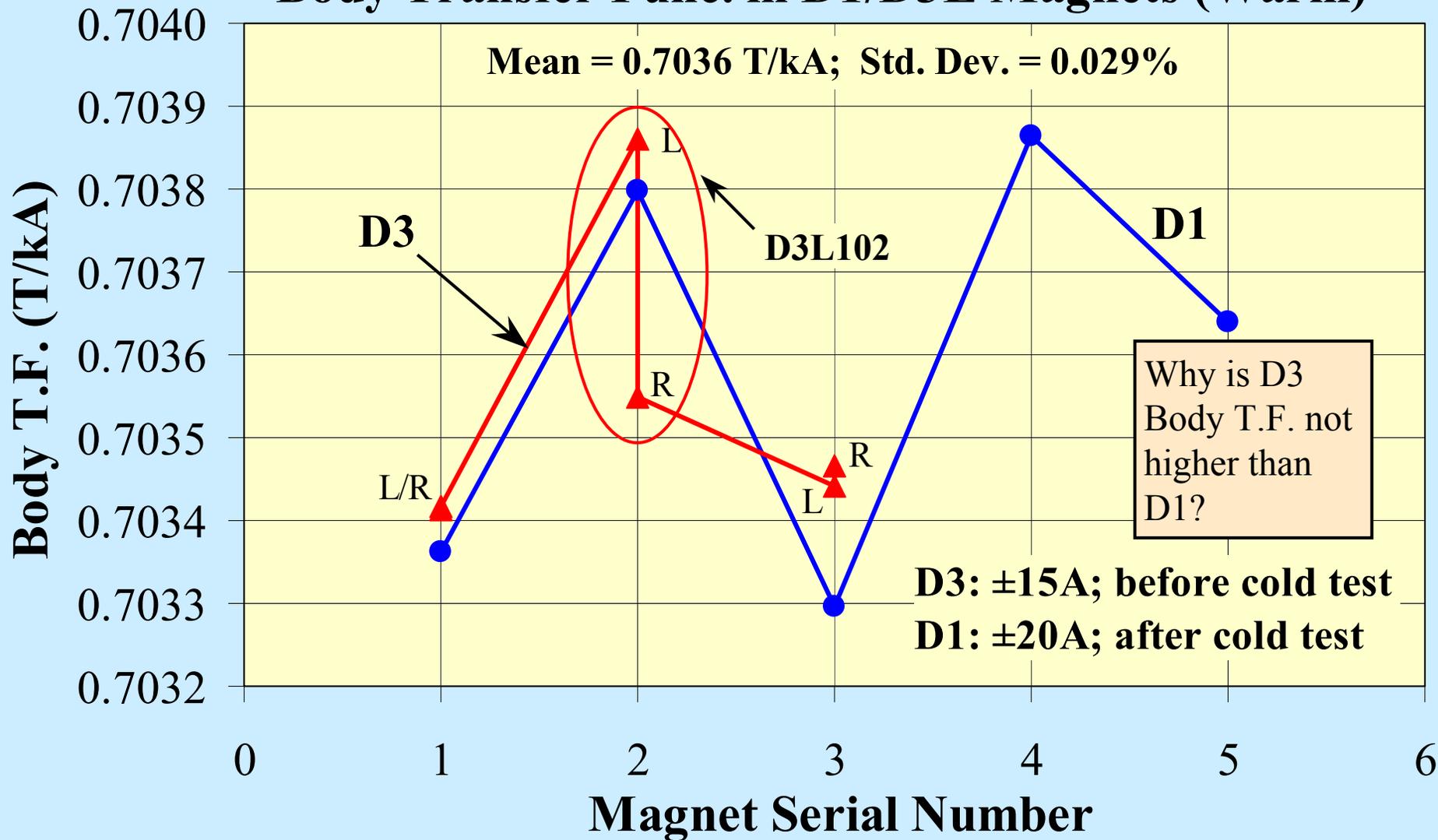


Integral Trans. Func. in D1/D3L Magnets (Warm)



Individual cold masses in D3L101, when measured with a cycle used in D1, showed no change in the measured ITF

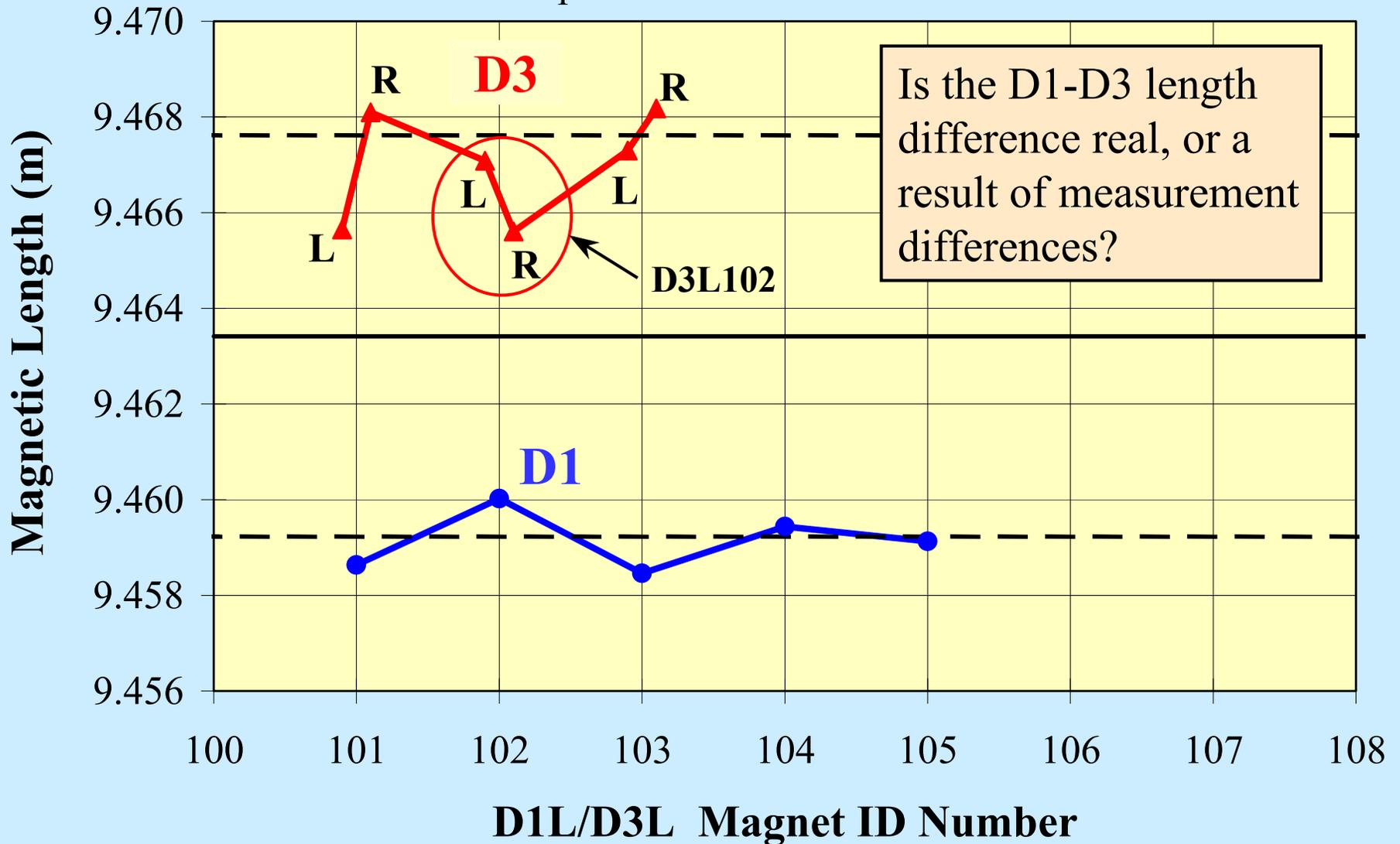
Body Transfer Func. in D1/D3L Magnets (Warm)



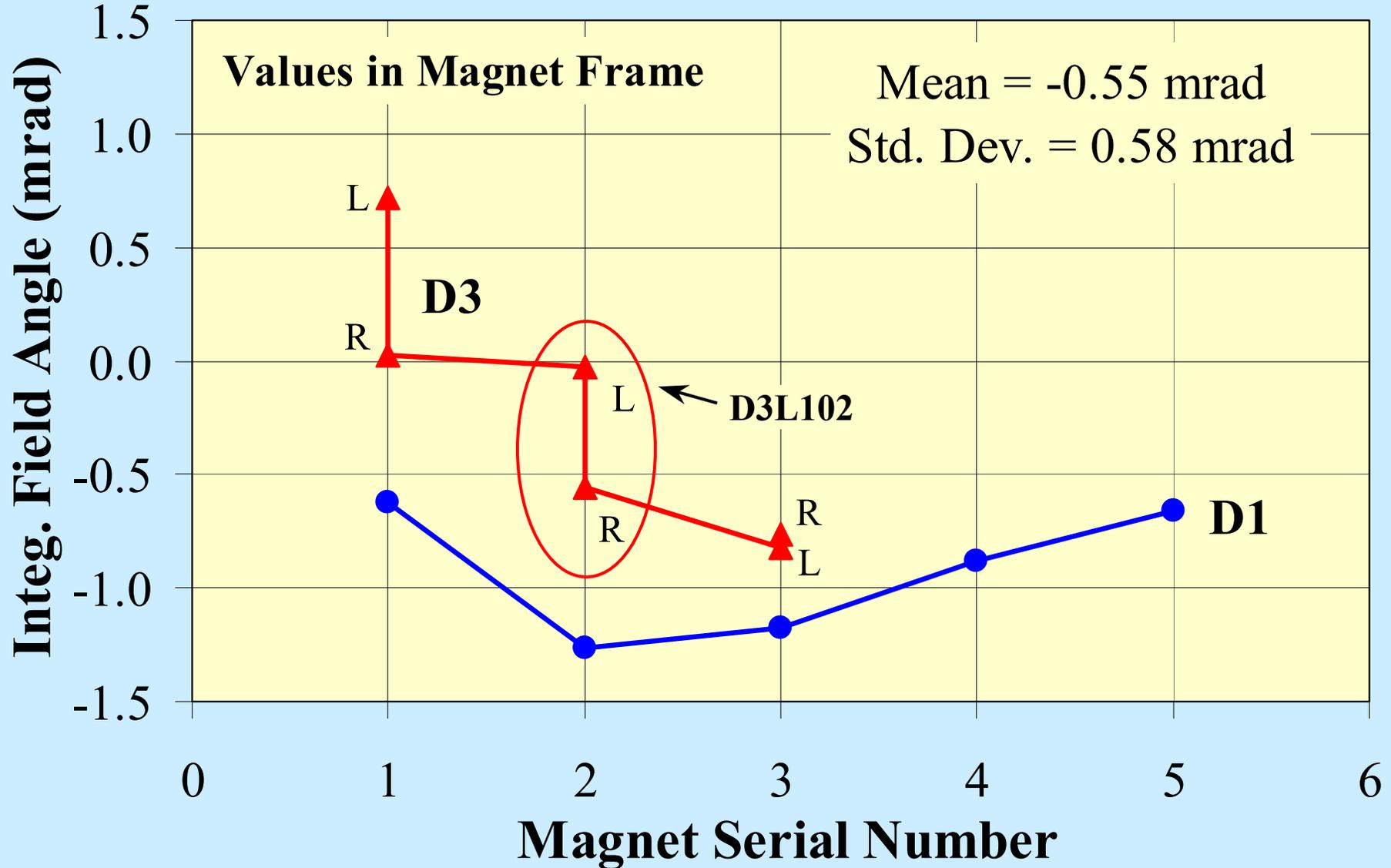
Body T.F. was not measured for individual cold mass in any D3L.

D1L/D3L Dipoles -- Magnetic Length (Warm)

11 Apertures : Mean = 9.463 STD Dev. = 0.004



Integ. Field Angle in D1/D3 Magnets (Warm)



D3L102 Vs. Mean and Standard Deviation

Integral Normal Harmonics (Warm) in units at 25 mm

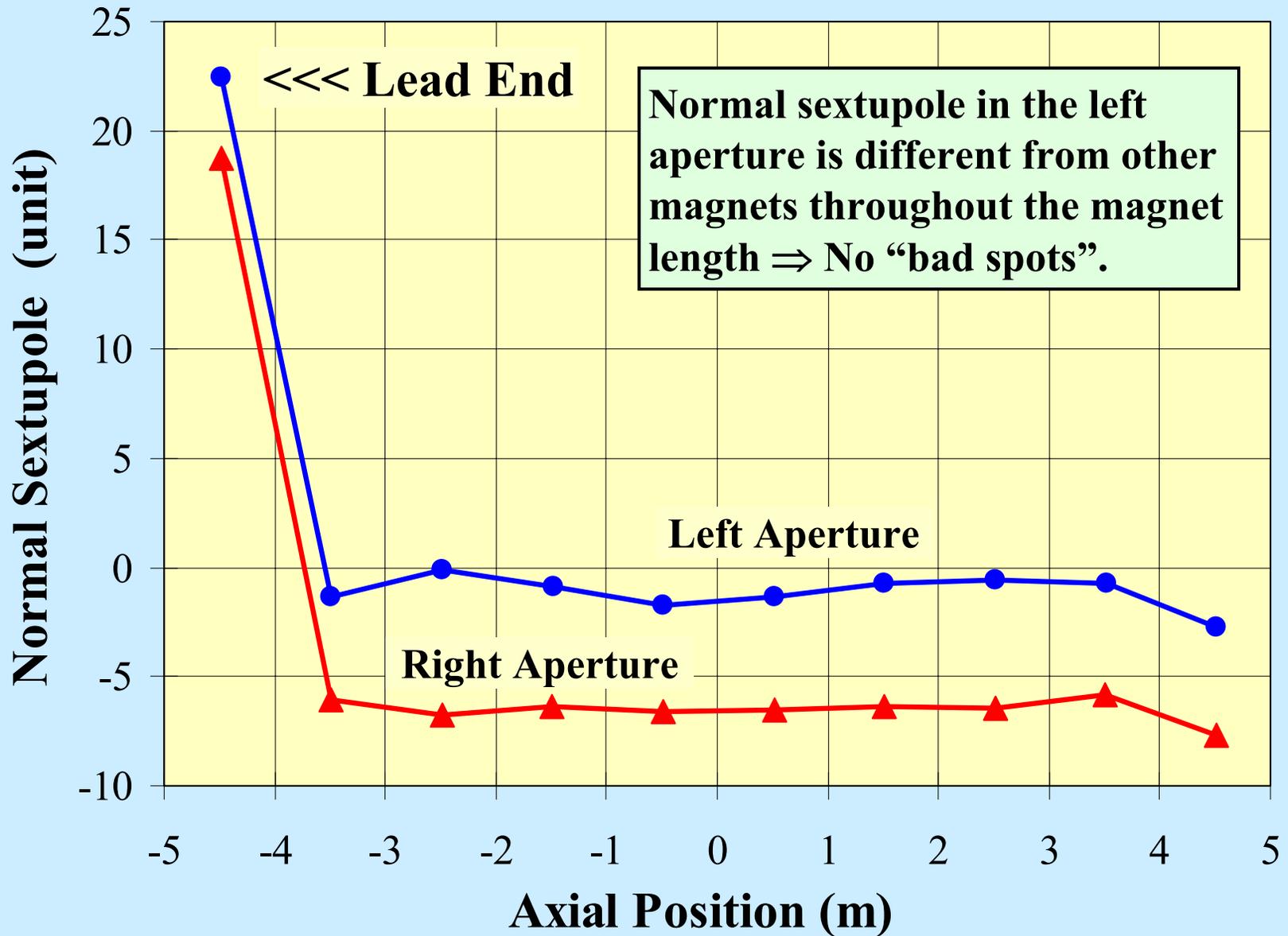
	D1L/D3L Mean	D1L/D3L Std.Dev.	D3L102(L)	No. of Sigma	D3L102(R)	No. of Sigma
I.T.F. (T.m/kA)	6.6580	0.050%	6.6635	1.6	6.6595	0.4
Quadrupole	-0.62	0.68	0.20	1.2	-0.58	0.1
Sextupole	-2.94	1.70	0.78	2.2	-4.49	-0.9
Octupole	0.01	0.17	0.12	0.6	0.12	0.7
Decapole	0.50	0.20	0.80	1.5	0.31	-1.0
12-pole	-0.04	0.07	0.01	0.8	-0.04	0.0
14-pole	0.03	0.16	0.06	0.2	0.14	0.7
16-pole	-0.01	0.02	-0.04	-1.4	-0.02	-0.4
18-pole	-0.10	0.03	-0.13	-1.0	-0.11	-0.2
20-pole	0.00	0.02	0.00	0.1	-0.02	-0.7
22-pole	-0.62	0.02	-0.62	0.4	-0.60	1.0
24-pole	0.00	0.01	0.01	0.5	0.00	-0.5
26-pole	-0.18	0.03	-0.18	0.2	-0.15	1.1

D3L102 Vs. Mean and Standard Deviation

Integral Skew Harmonics (Warm) in units at 25 mm

	D1L/D3L Mean	D1L/D3L Std.Dev.	D3L102(L)	No. of Sigma	D3L102(R)	No. of Sigma
Field Angle (mrad)	-0.55	0.58	-0.02	0.9	-0.56	0.0
Quadrupole	-0.93	2.61	0.57	0.6	0.38	0.5
Sextupole	-0.89	0.14	-0.68	1.4	-1.03	-1.0
Octupole	0.08	0.69	1.28	1.7	0.36	0.4
Decapole	0.20	0.07	0.15	-0.7	0.16	-0.6
12-pole	0.01	0.20	0.35	1.7	-0.01	-0.1
14-pole	-0.11	0.03	-0.09	0.5	-0.13	-0.7
16-pole	0.00	0.06	0.03	0.5	-0.03	-0.6
18-pole	0.01	0.02	0.04	1.2	0.00	-0.6
20-pole	0.03	0.02	0.03	-0.1	0.01	-1.0
22-pole	-0.01	0.02	0.01	0.8	-0.01	0.2
24-pole	0.00	0.01	0.00	-0.7	0.00	0.0
26-pole	0.00	0.01	-0.01	-0.4	0.00	0.2

Normal Sextupole (Warm) in D3L102



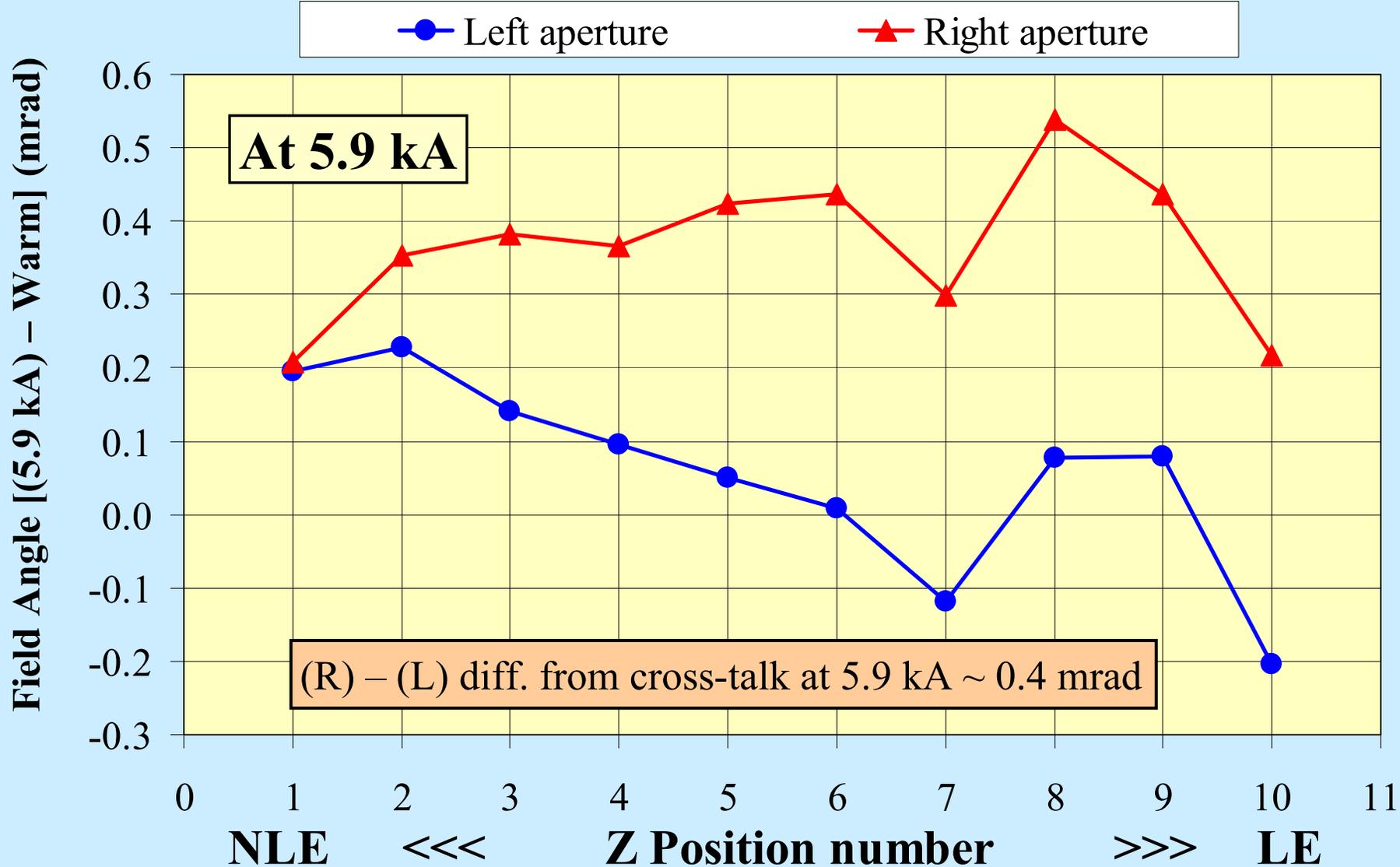
Cold Measurements

- Sparse excitation curves (19 currents) were measured at each of the 10 axial positions, in each aperture.
- The 19 currents in the sparse loop cover 200A (0.14 T) to 5900A (3.9 T).
- The integral T.F. is obtained from Z-scan only, and can have errors of up to $\sim 0.1\%$. (Warm-cold correlations for D3L102 are in agreement with most other D3 apertures.)
- Down ramp measurements are done at only one position in each aperture.
- Dynamic measurements, consisting of time decay and harmonic measurements during a ramp, were also made in D3L102.

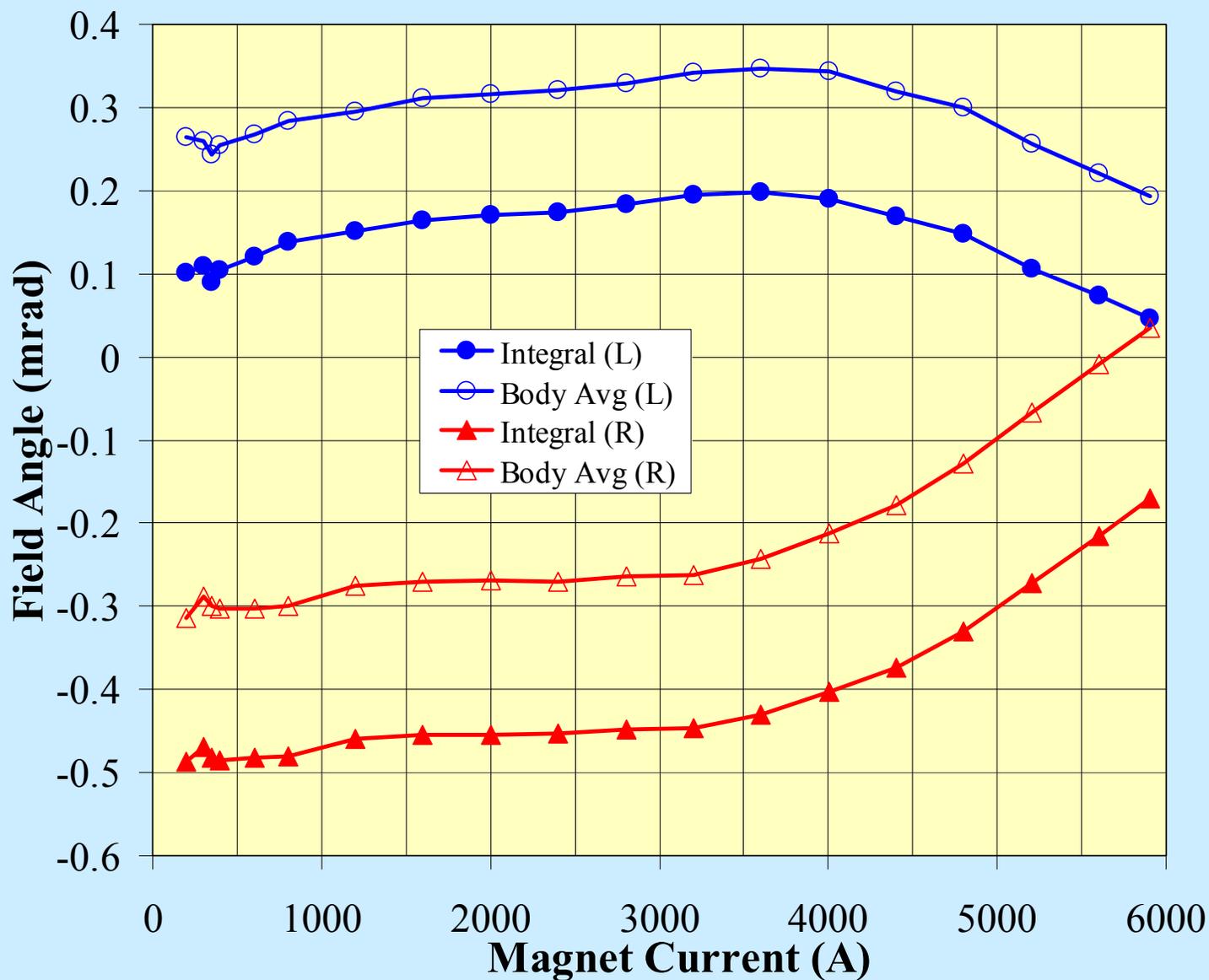
Field Angle Changes on Cool Down in D3L102



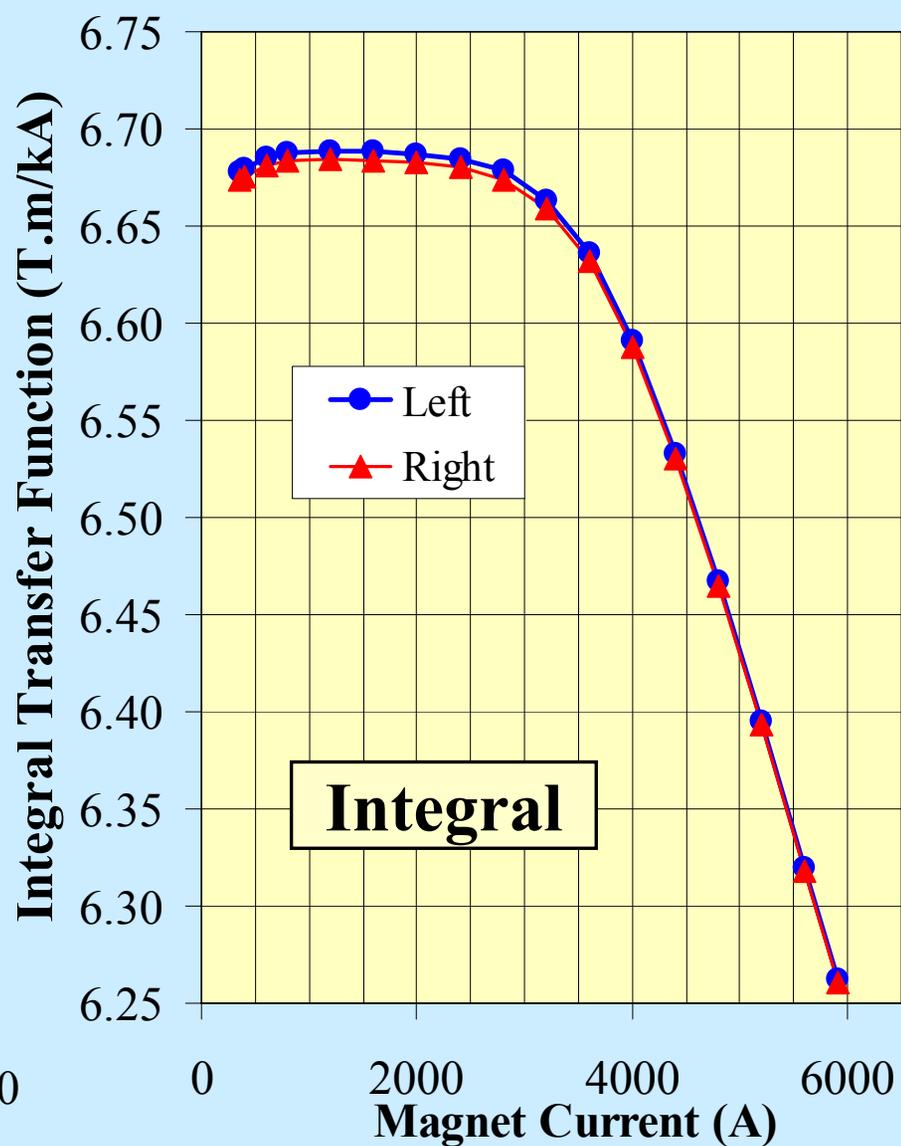
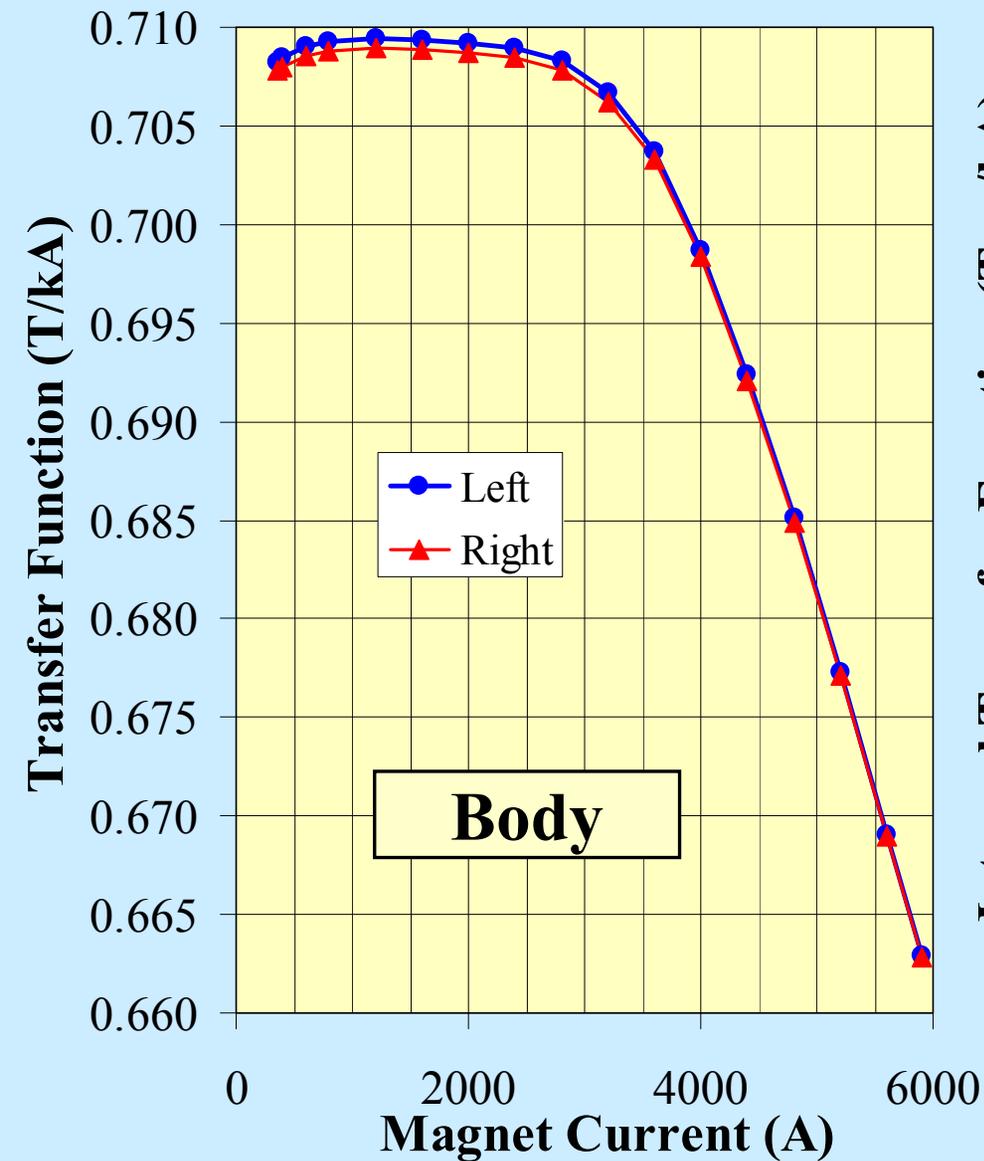
Field Angle Changes on Cool Down in D3L102



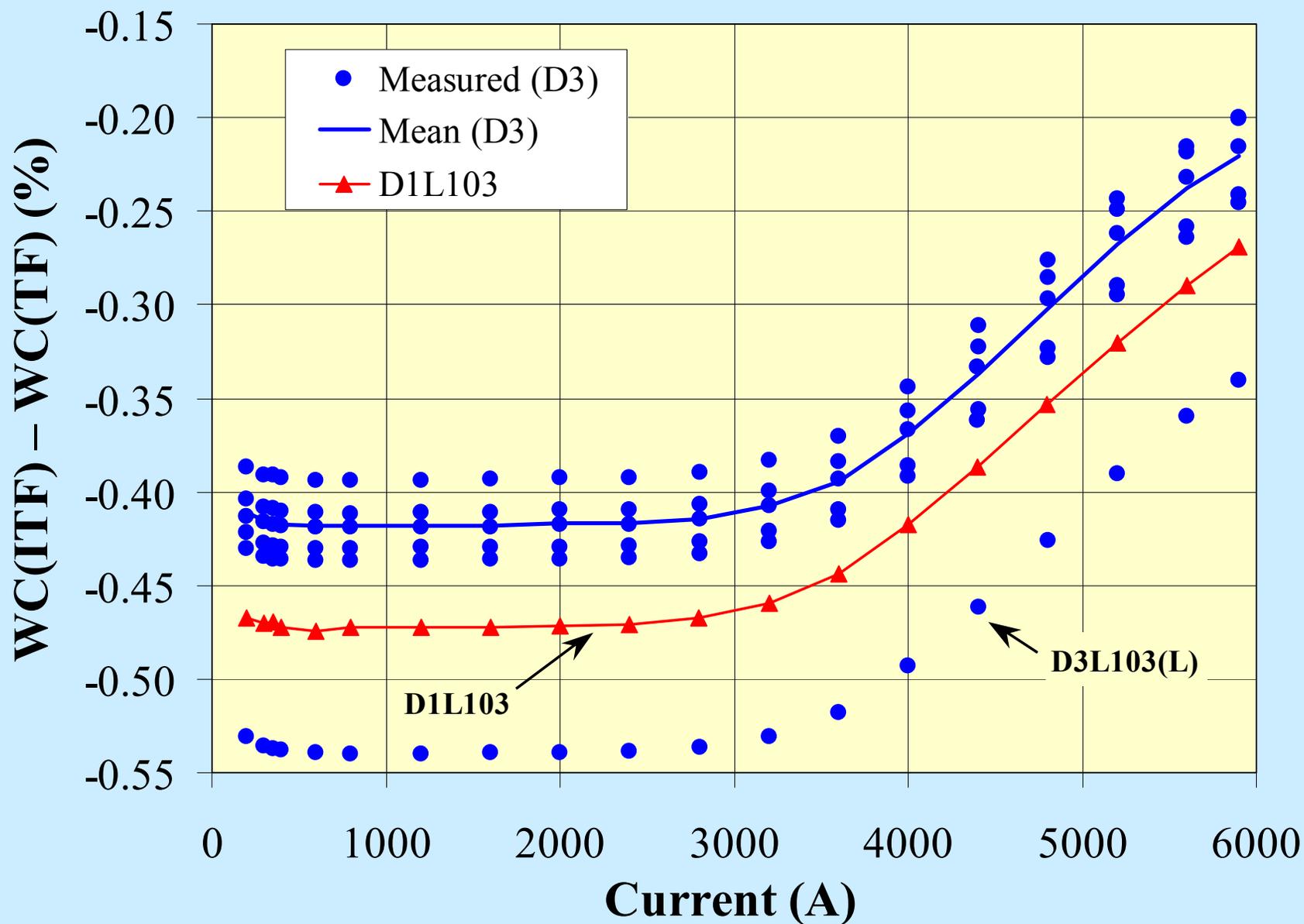
St. Section and Integral Field Angles in D3L102



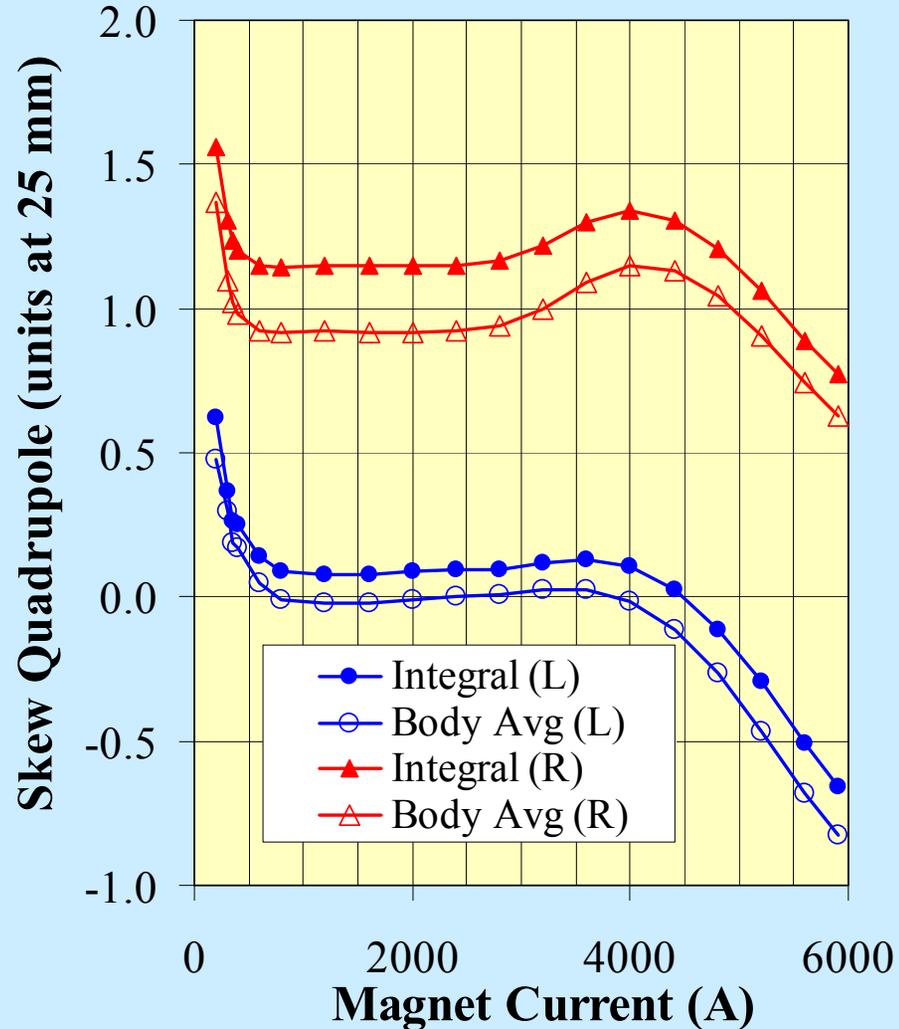
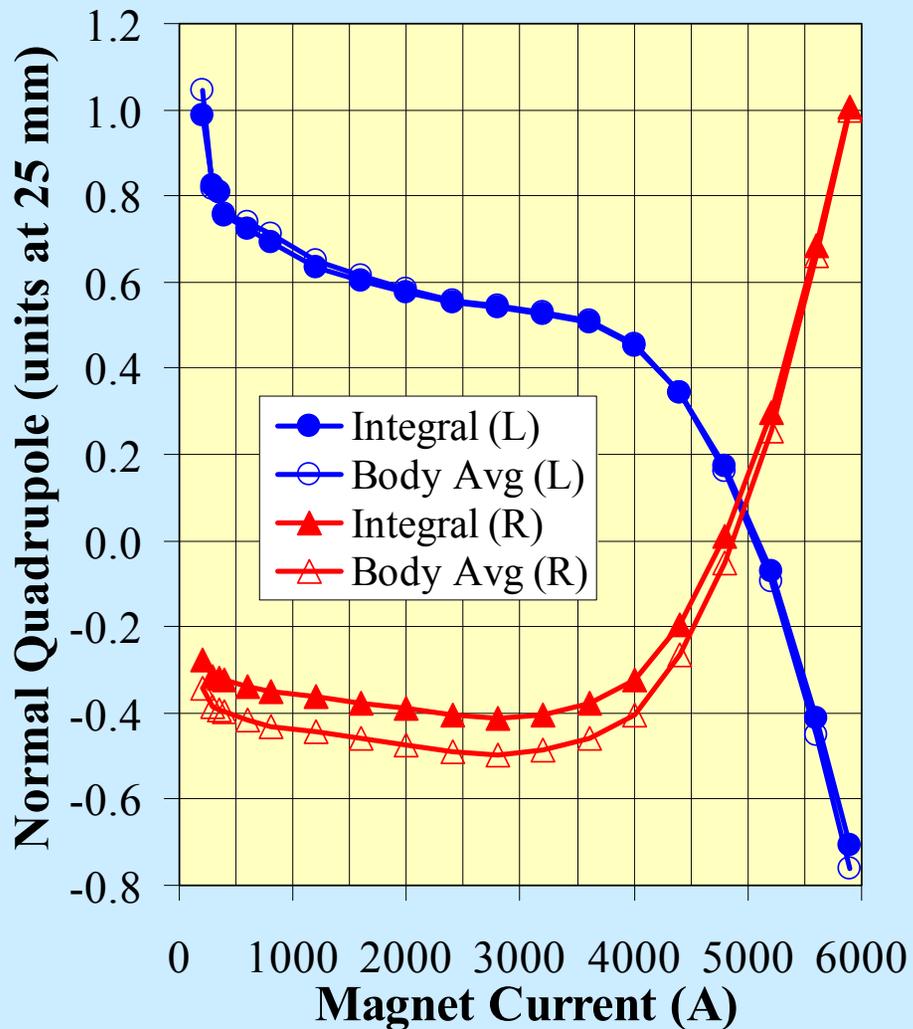
St. Section and Integral T.F. in D3L102



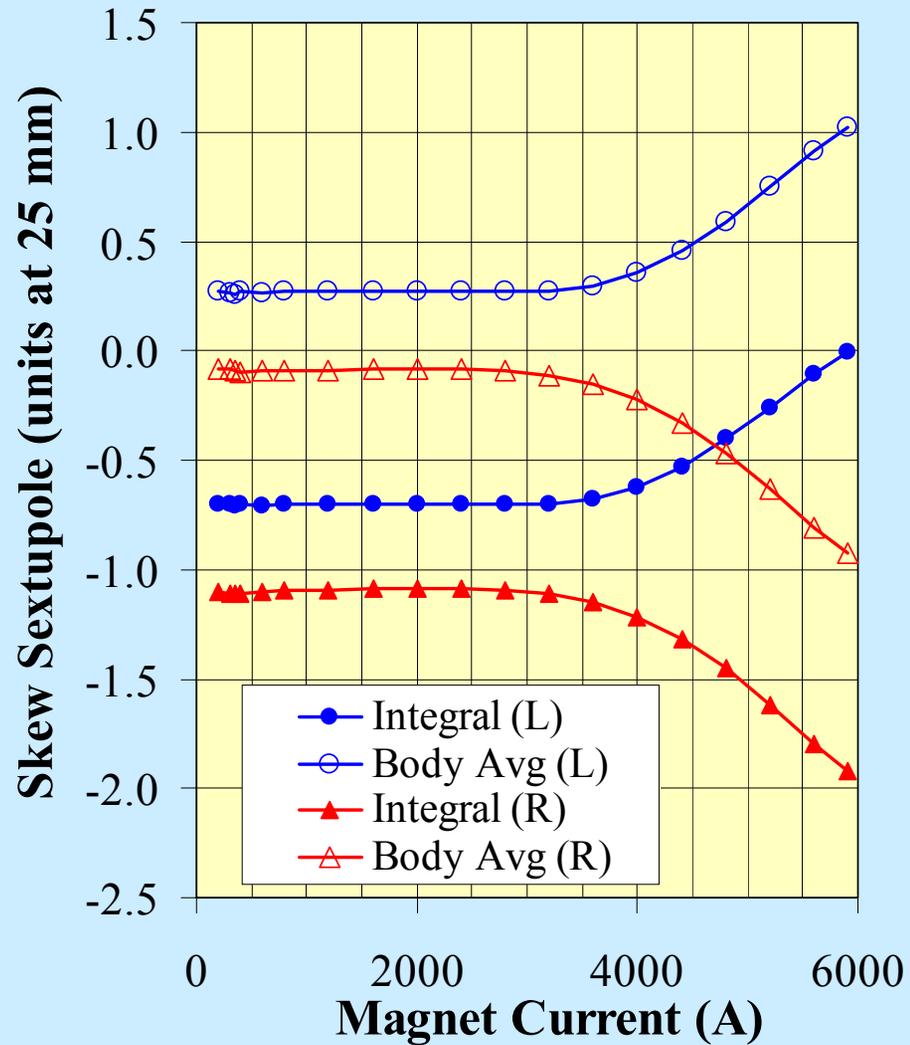
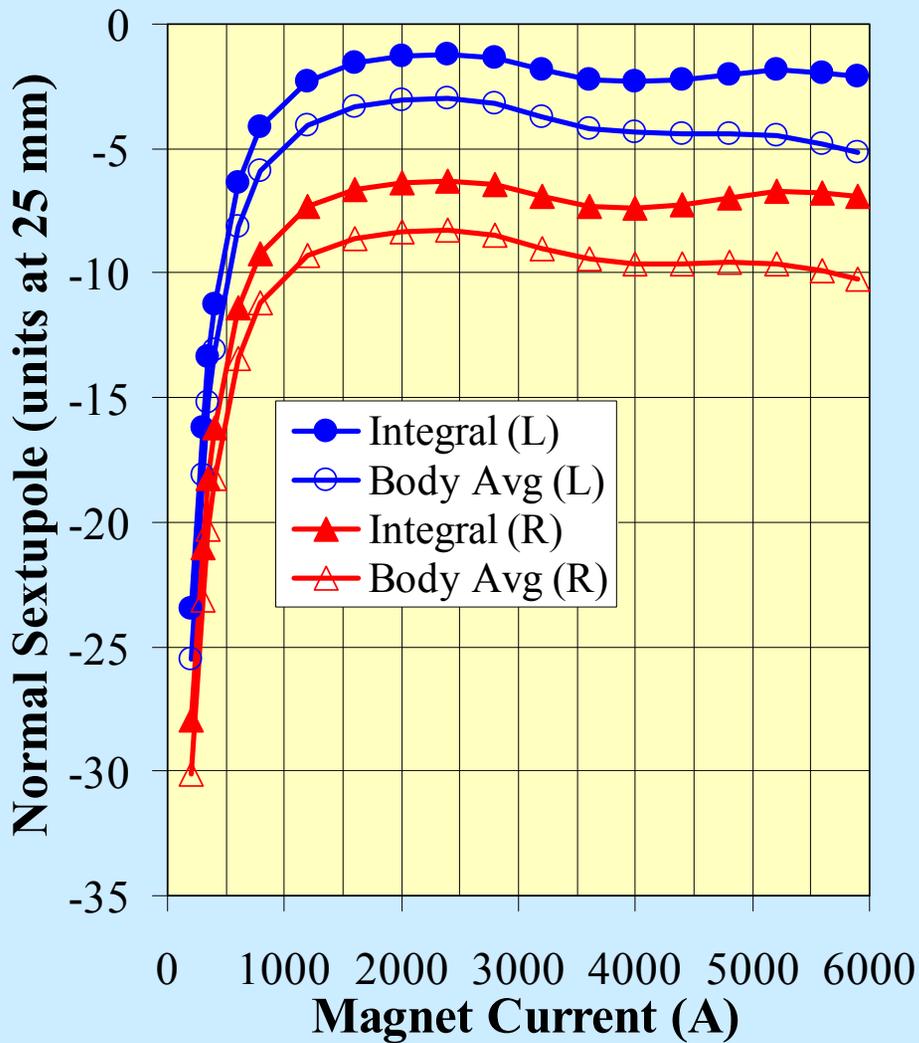
Body TF and ITF W-C Offset differences as a function of Current



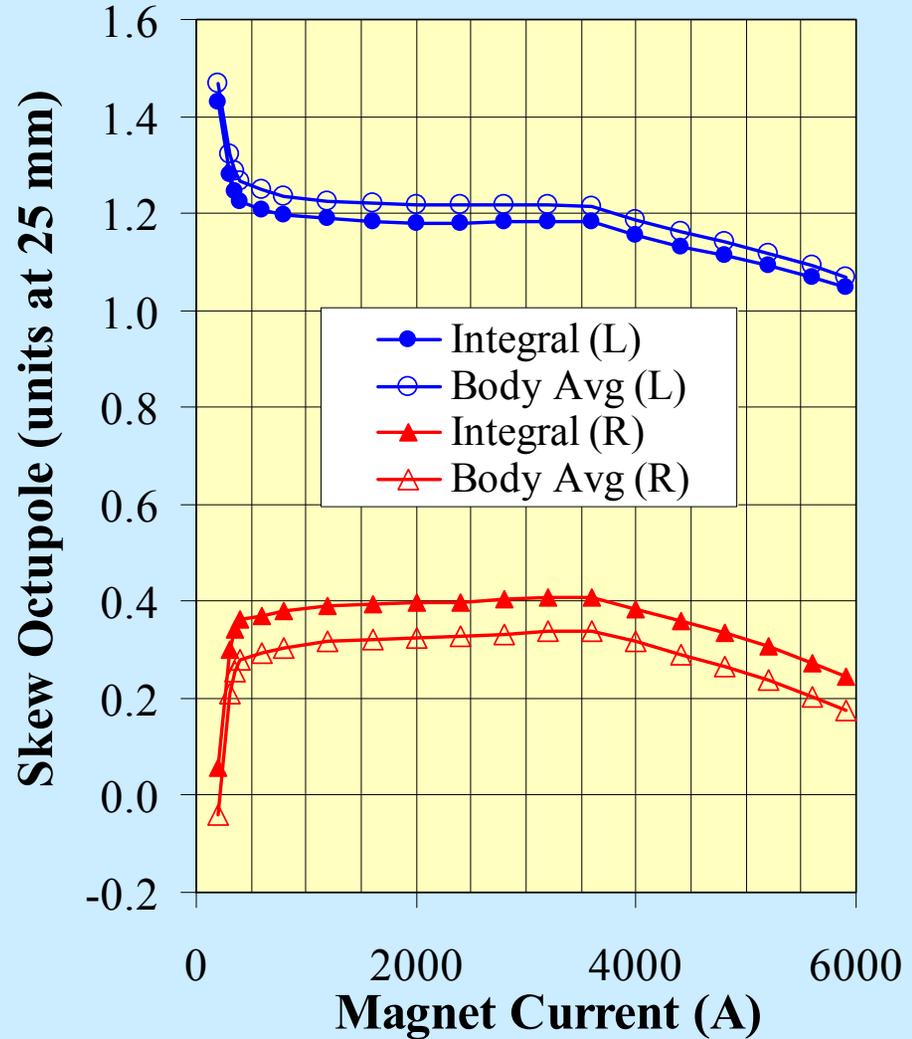
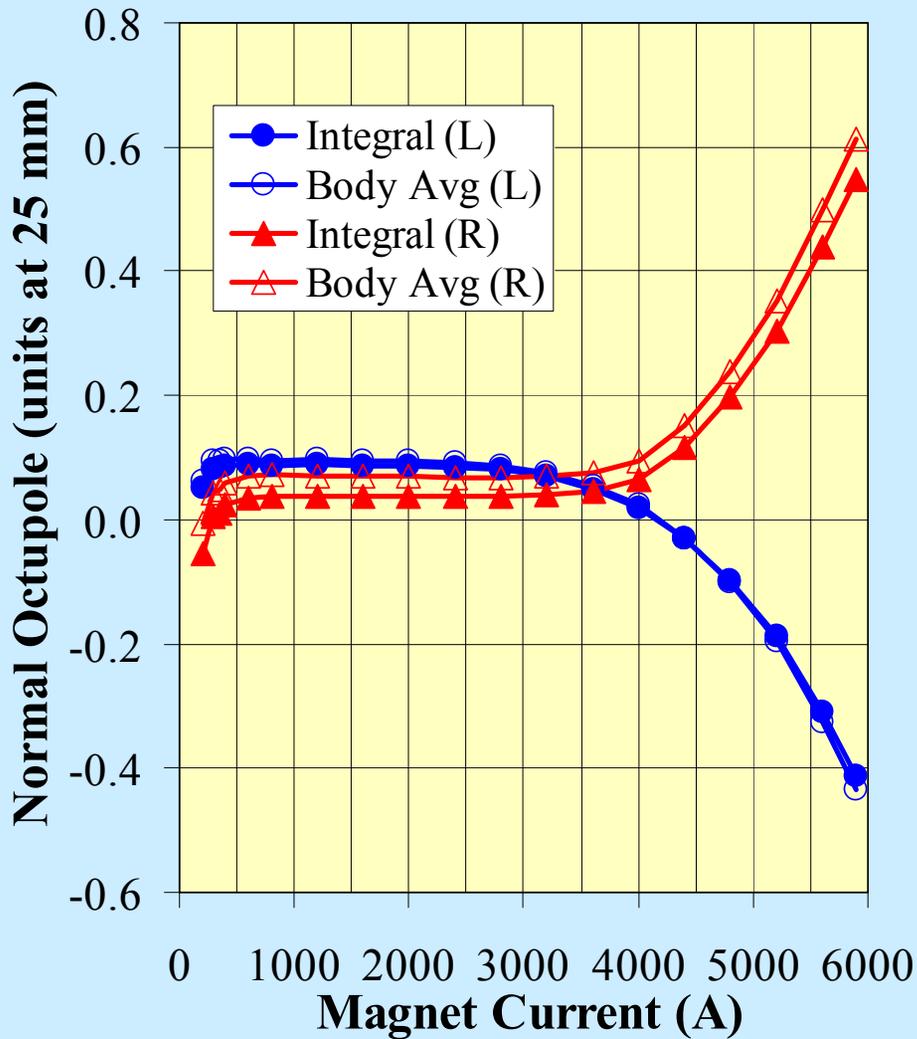
Quadrupole Terms in D3L102



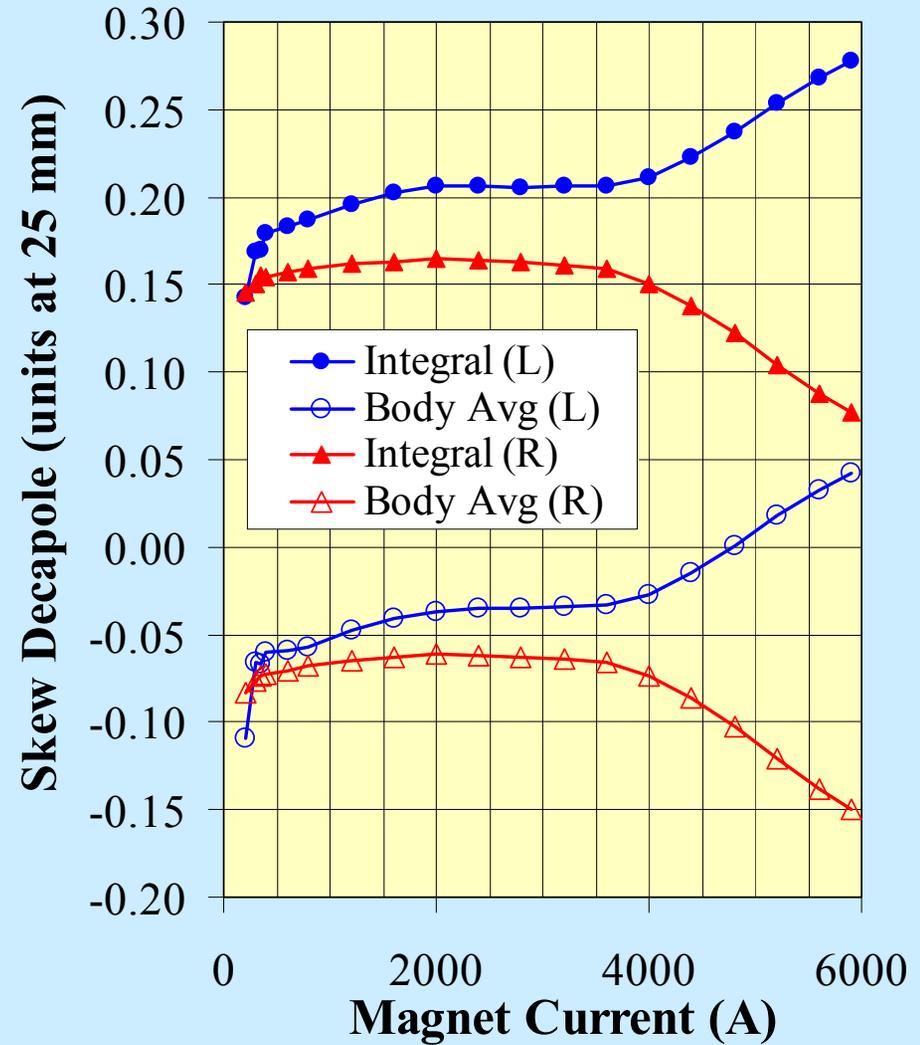
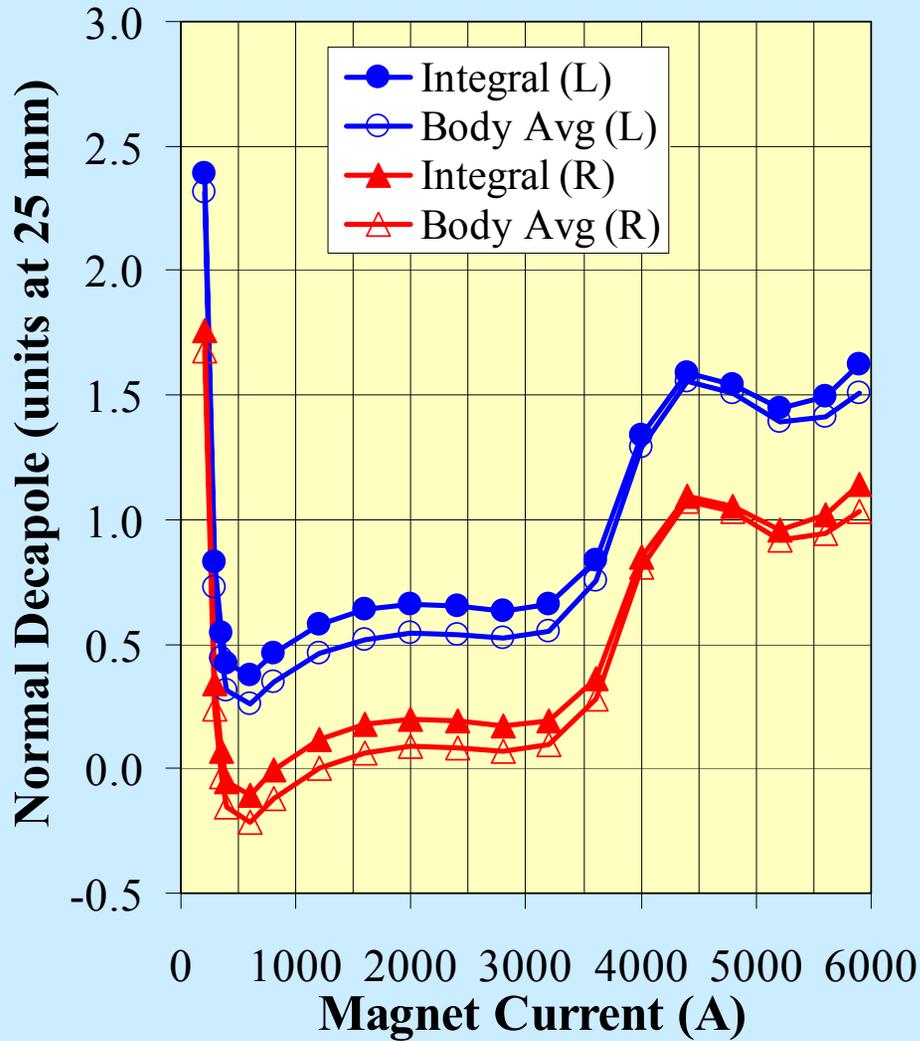
Sextupole Terms in D3L102



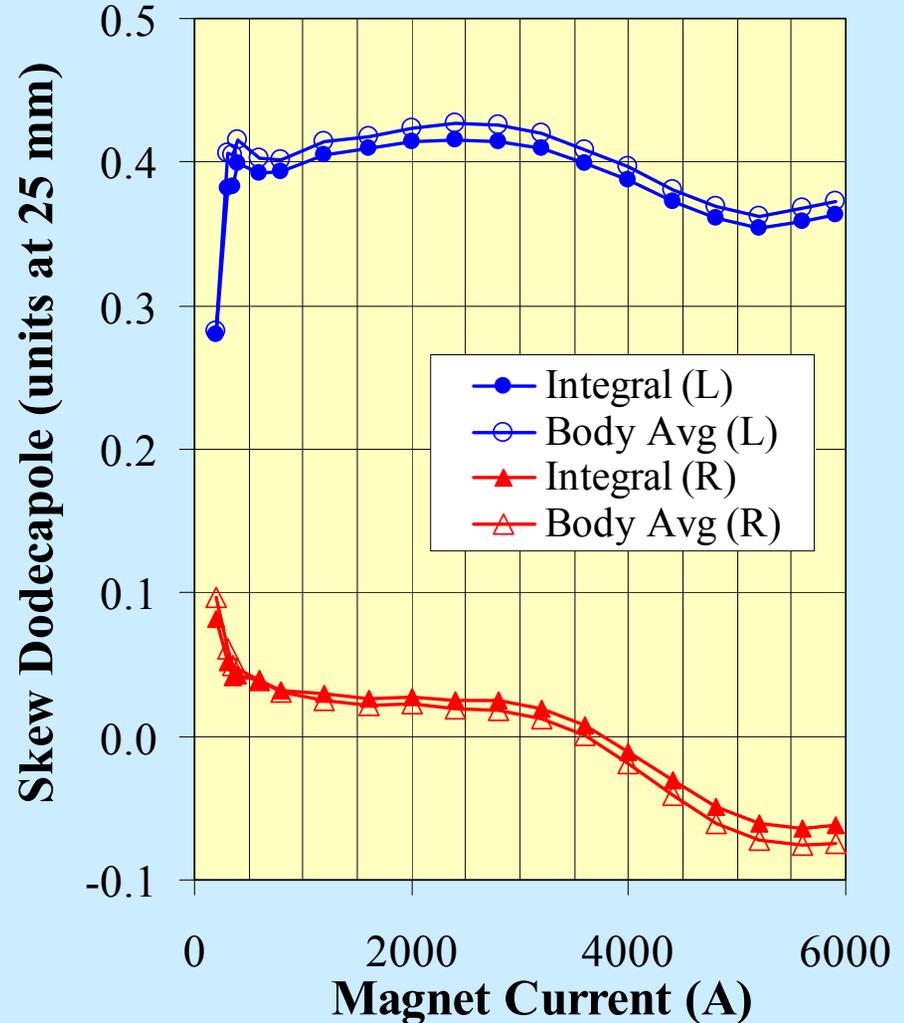
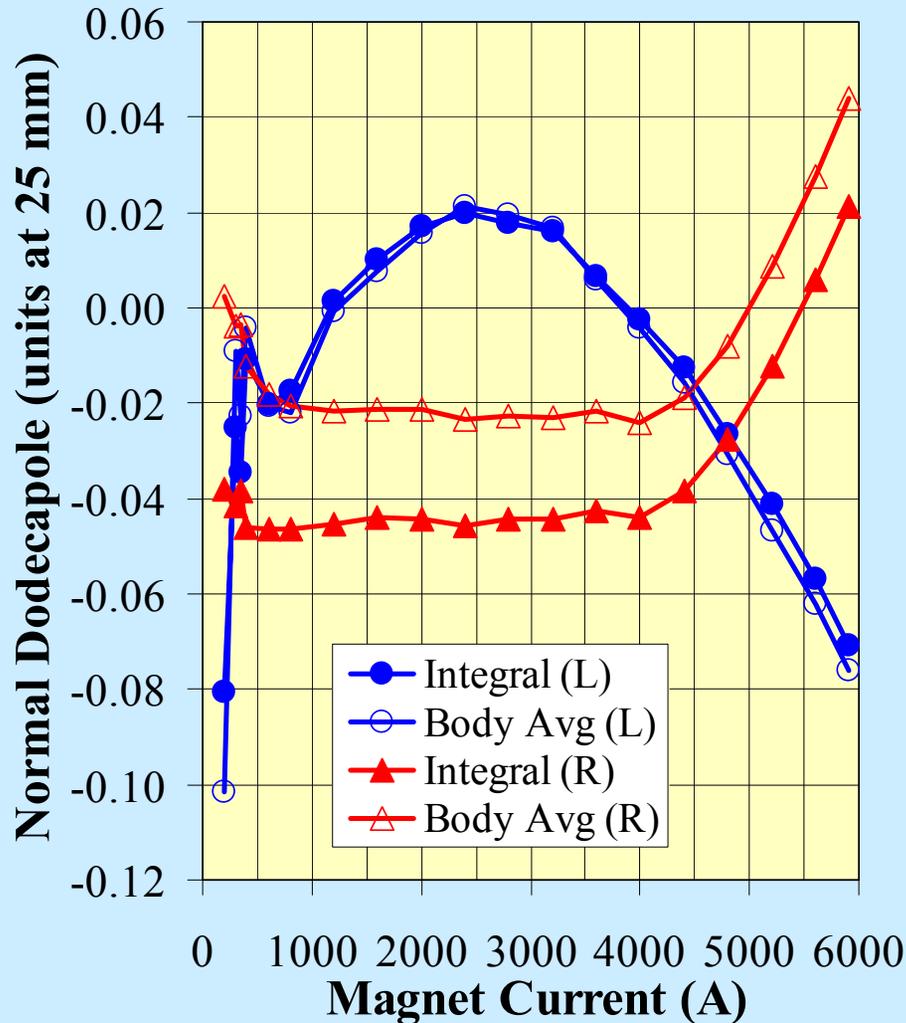
Octupole Terms in D3L102



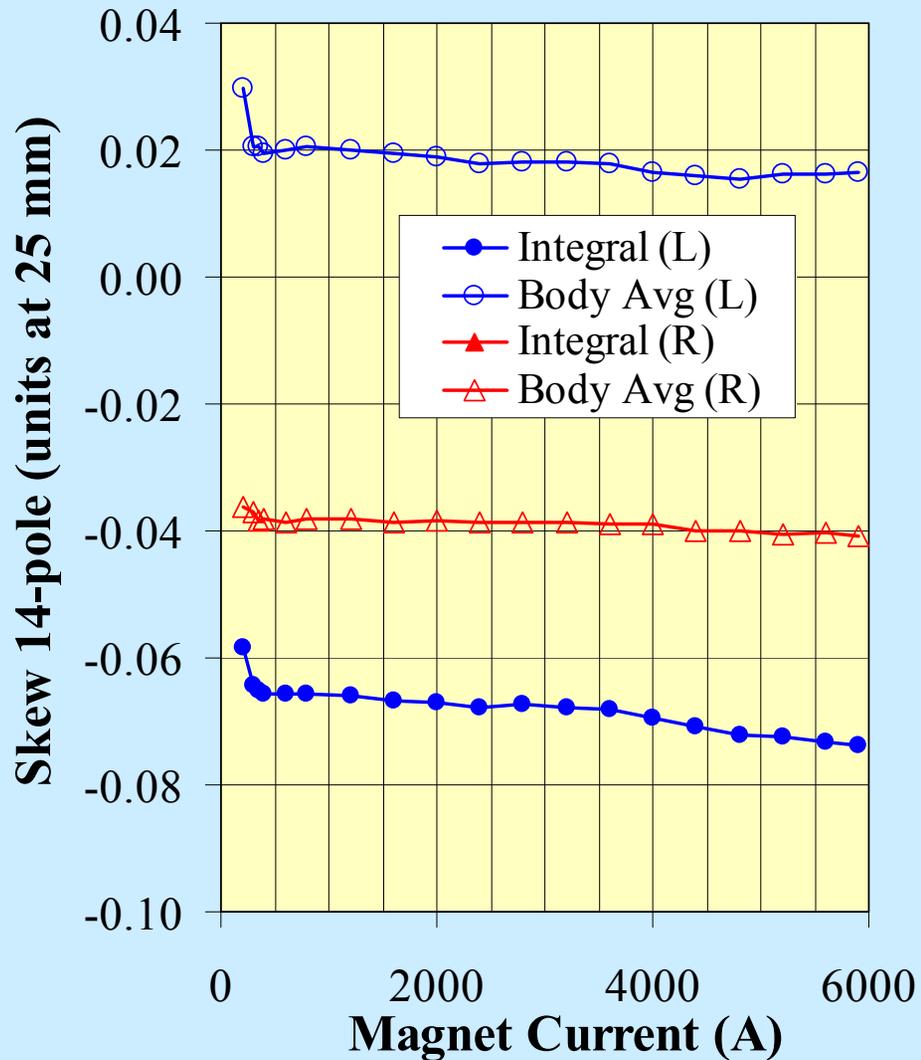
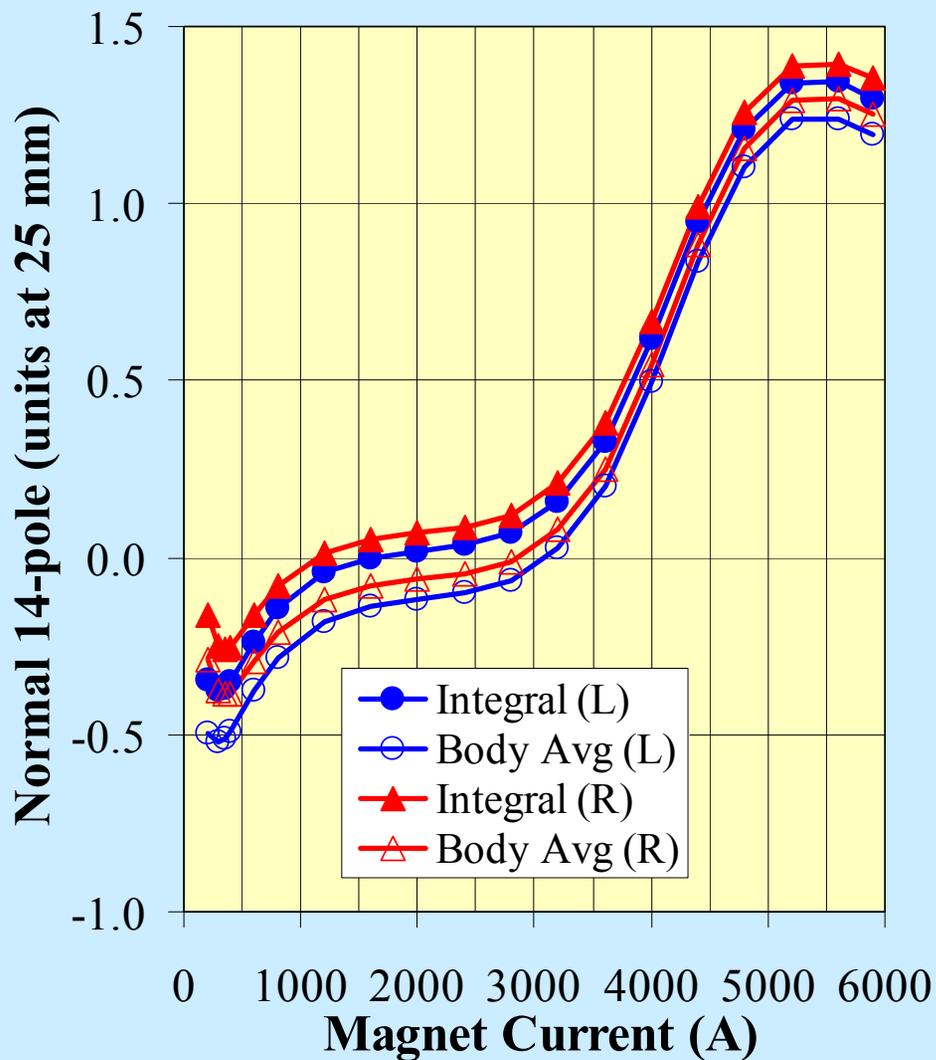
Decapole Terms in D3L102



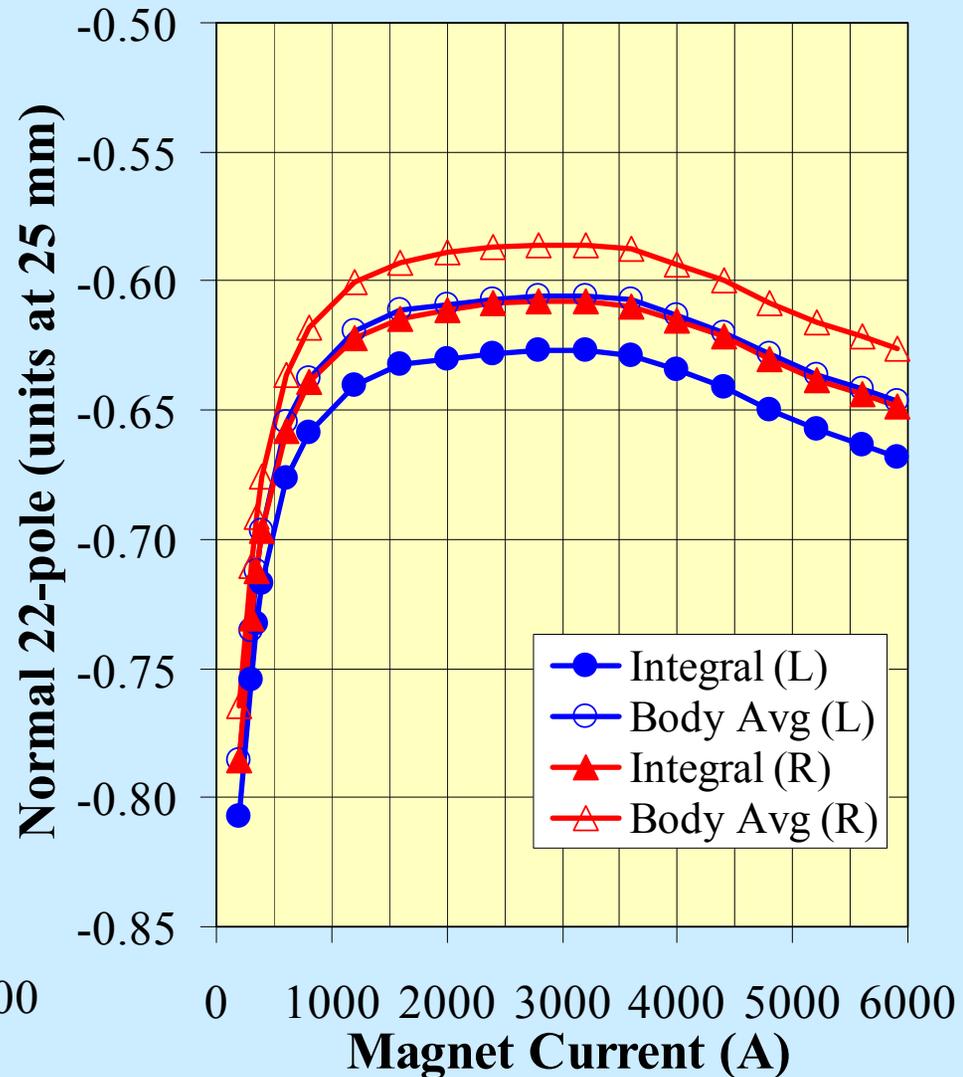
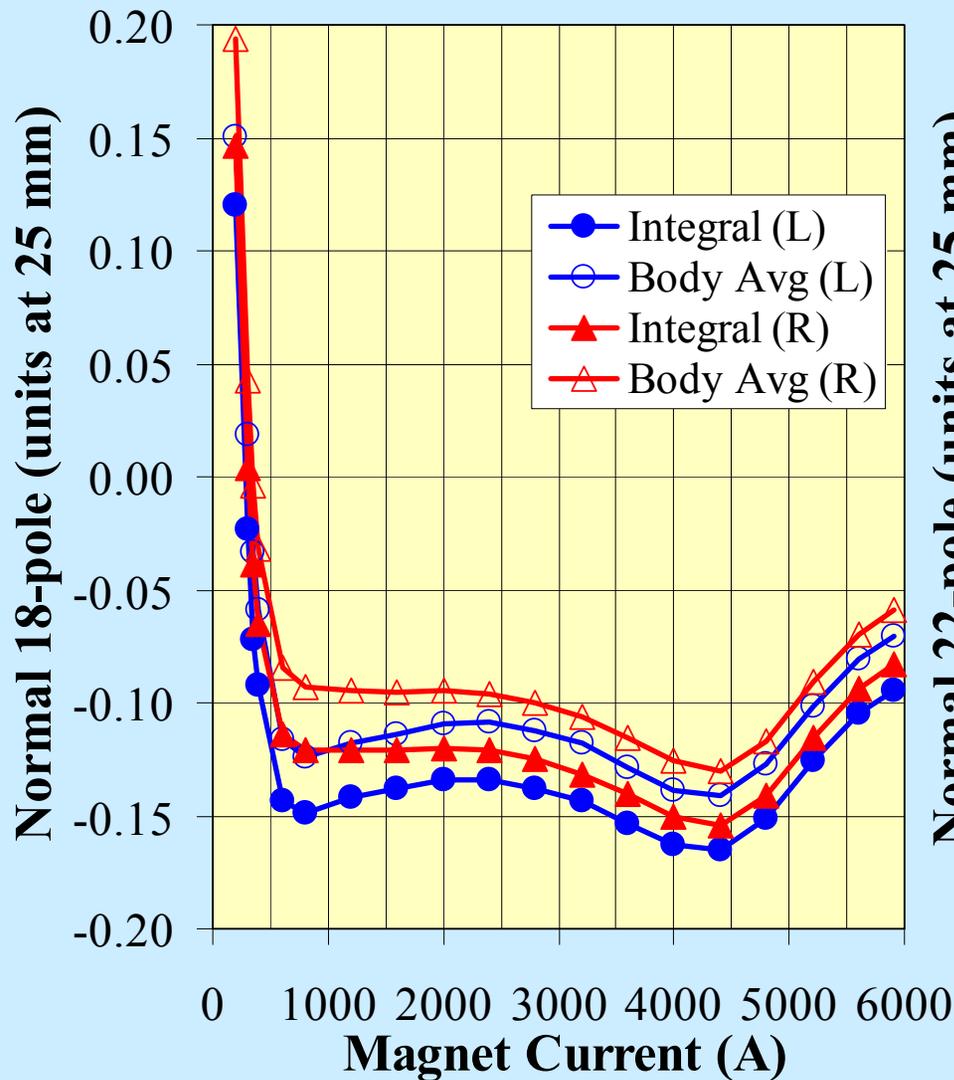
Dodecapole Terms in D3L102



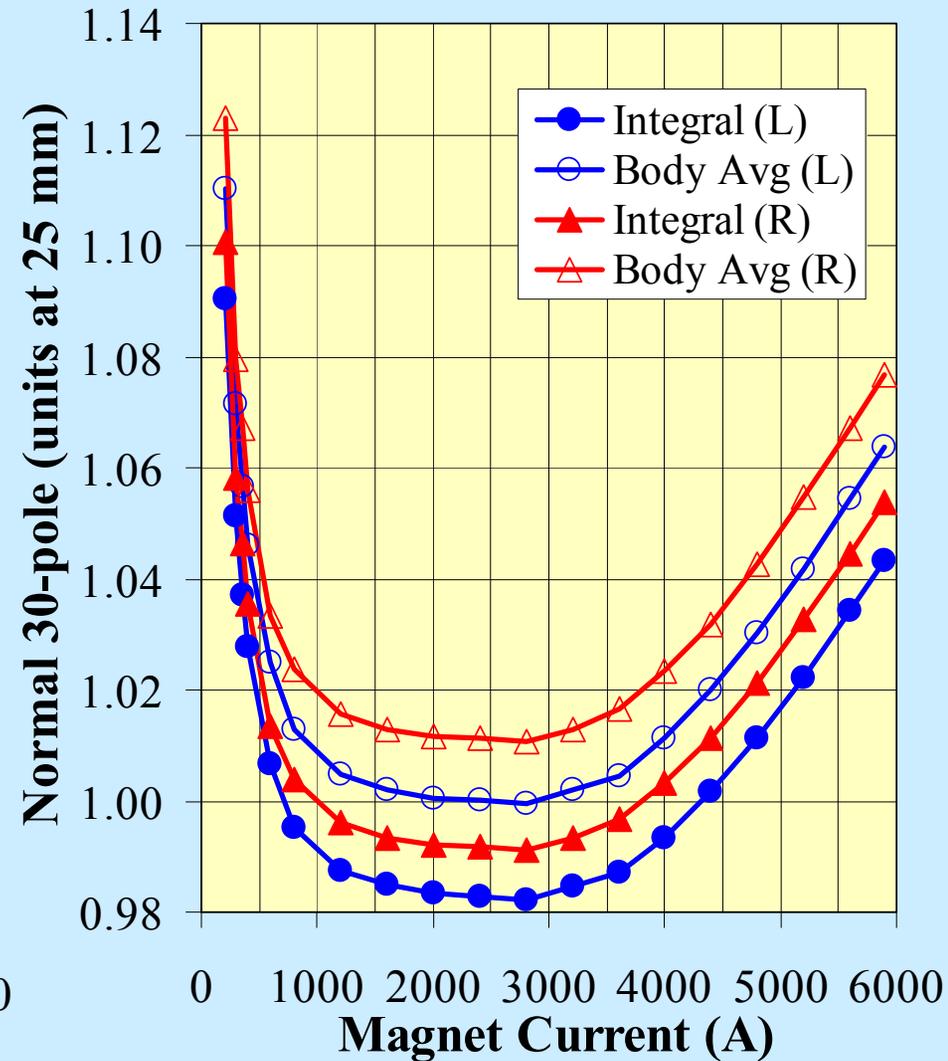
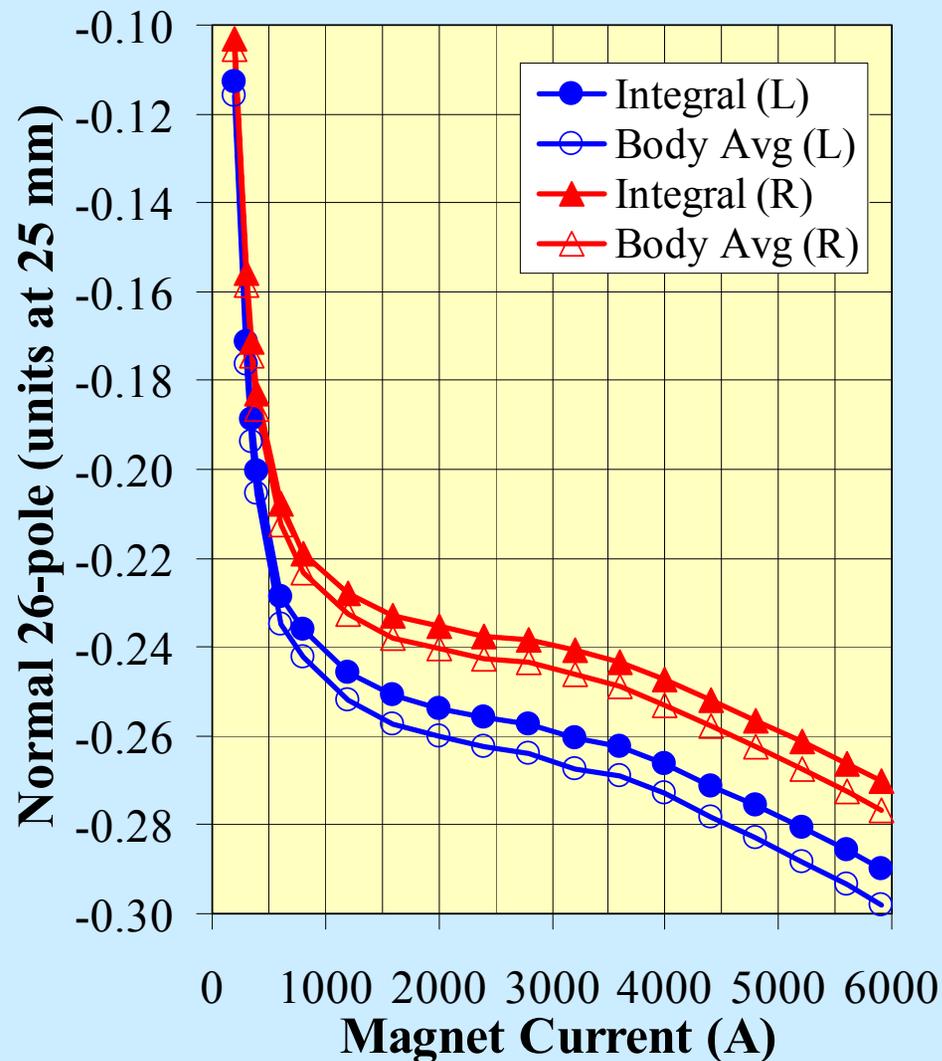
14-pole Terms in D3L102



Normal 18-pole and 22-pole Terms in D3L102



Normal 26-pole and 30-pole Terms in D3L102



Comparison of Field Quality in D3L102 with the Expected Ver 1.0 Tables

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 300A (0.2 Tesla)

n	<bn>	Δ (bn)	σ (bn)	<an>	Δ (an)	σ (an)
2	0.11	0.77	0.28	-0.09	3.68	1.53
3	-11.26	5.52	1.95	-1.10	0.49	0.17
4	-0.05	0.20	0.08	0.12	1.15	0.42
5	0.62	0.83	0.40	0.18	0.16	0.06
6	-0.01	0.08	0.03	-0.03	0.54	0.15
7	-0.27	0.21	0.10	-0.09	0.07	0.02
8	-0.03	0.03	0.01	-0.01	0.15	0.05
9	0.14	0.13	0.04	0.02	0.03	0.01
10	0.03	0.05	0.02	0.02	0.05	0.02
11	-0.66	0.04	0.02	-0.01	0.02	0.01

Measured Data in D3L102 & Ver 1.0 Comparison

Integral; 0.2 Tesla (interpolated) at 25 mm radius

n	bn(L)	bn(R)	an(L)	an(R)
2	0.85	-0.31	0.41	1.35
3	-17.49	-22.21	-0.70	-1.11
4	0.08	-0.01	1.31	0.26
5	1.10	0.59	0.16	0.15
6	-0.03	-0.04	0.36	0.06
7	-0.37	-0.24	-0.06	-0.11
8	-0.01	-0.02	0.04	-0.08
9	0.00	0.03	0.02	0.01
10	0.01	0.00	0.10	0.07
11	-0.76	-0.74	-0.03	-0.01

n	bn(L)	bn(R)	an(L)	an(R)
2	OK	OK	OK	OK
3	OK	??	OK	OK
4	OK	OK	OK	OK
5	OK	OK	OK	OK
6	OK	OK	OK	OK
7	OK	OK	OK	OK
8	OK	OK	OK	OK
9	OK	OK	OK	OK
10	OK	OK	??	OK
11	??	??	OK	OK

Ver.1.0 known issues: Systematic b3 difference from RHIC production; No cross-talk at high field included for D3.

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 3.8 Tesla (5700 A)

n	<bn>	Δ (bn)	σ (bn)	<an>	Δ (an)	σ (an)
2	0.25	0.79	0.28	0.54	3.71	1.51
3	-1.71	3.57	1.70	-1.31	0.55	0.18
4	0.07	0.21	0.08	0.06	1.08	0.41
5	0.24	0.80	0.39	0.16	0.17	0.06
6	-0.12	0.10	0.04	-0.05	0.55	0.16
7	1.17	0.19	0.10	-0.11	0.06	0.02
8	-0.02	0.03	0.01	-0.01	0.15	0.05
9	0.01	0.12	0.04	0.01	0.03	0.01
10	0.04	0.05	0.02	0.04	0.04	0.02
11	-0.60	0.04	0.02	-0.01	0.01	0.01

Measured Data in D3L102 & Ver 1.0 Comparison

Integral; 3.8 Tesla (interpolated) at 25 mm radius

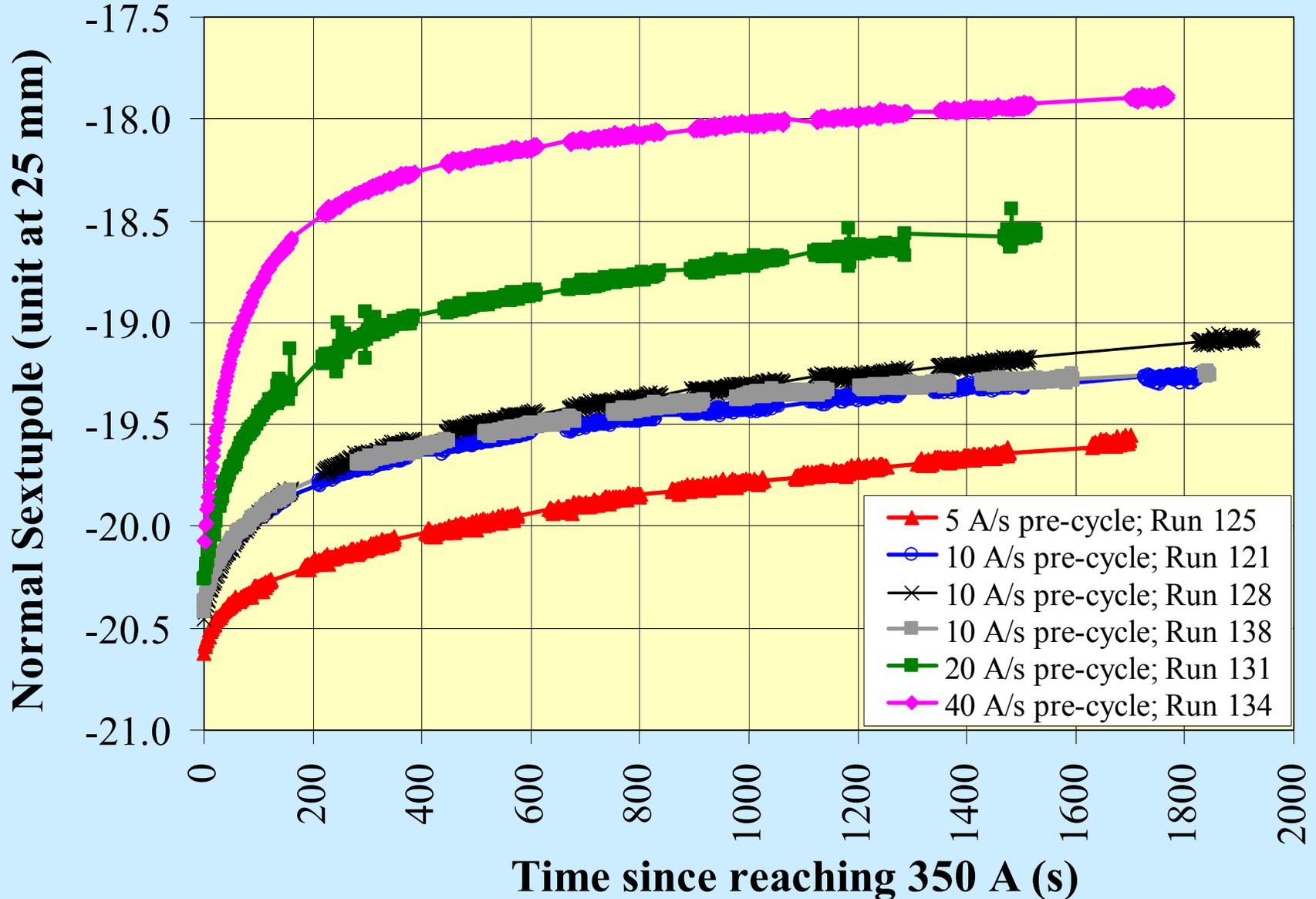
n	bn(L)	bn(R)	an(L)	an(R)
2	-0.51	0.79	-0.56	0.85
3	-1.99	-6.84	-0.08	-1.84
4	-0.34	0.47	1.06	0.26
5	1.54	1.06	0.27	0.08
6	-0.06	0.01	0.36	-0.06
7	1.33	1.38	-0.07	-0.14
8	-0.01	-0.01	0.05	-0.02
9	-0.10	-0.09	0.03	0.01
10	0.02	0.00	0.07	0.07
11	-0.67	-0.65	-0.01	-0.01

n	bn(L)	bn(R)	an(L)	an(R)
2	OK	OK	OK	OK
3	OK	OK	??	OK
4	??	??	OK	OK
5	??	OK	OK	OK
6	OK	OK	OK	OK
7	OK	OK	OK	OK
8	OK	OK	OK	OK
9	OK	OK	OK	OK
10	OK	OK	OK	OK
11	??	OK	OK	OK

OK=Value between (mean- Δ - σ) & (mean+ Δ + σ)

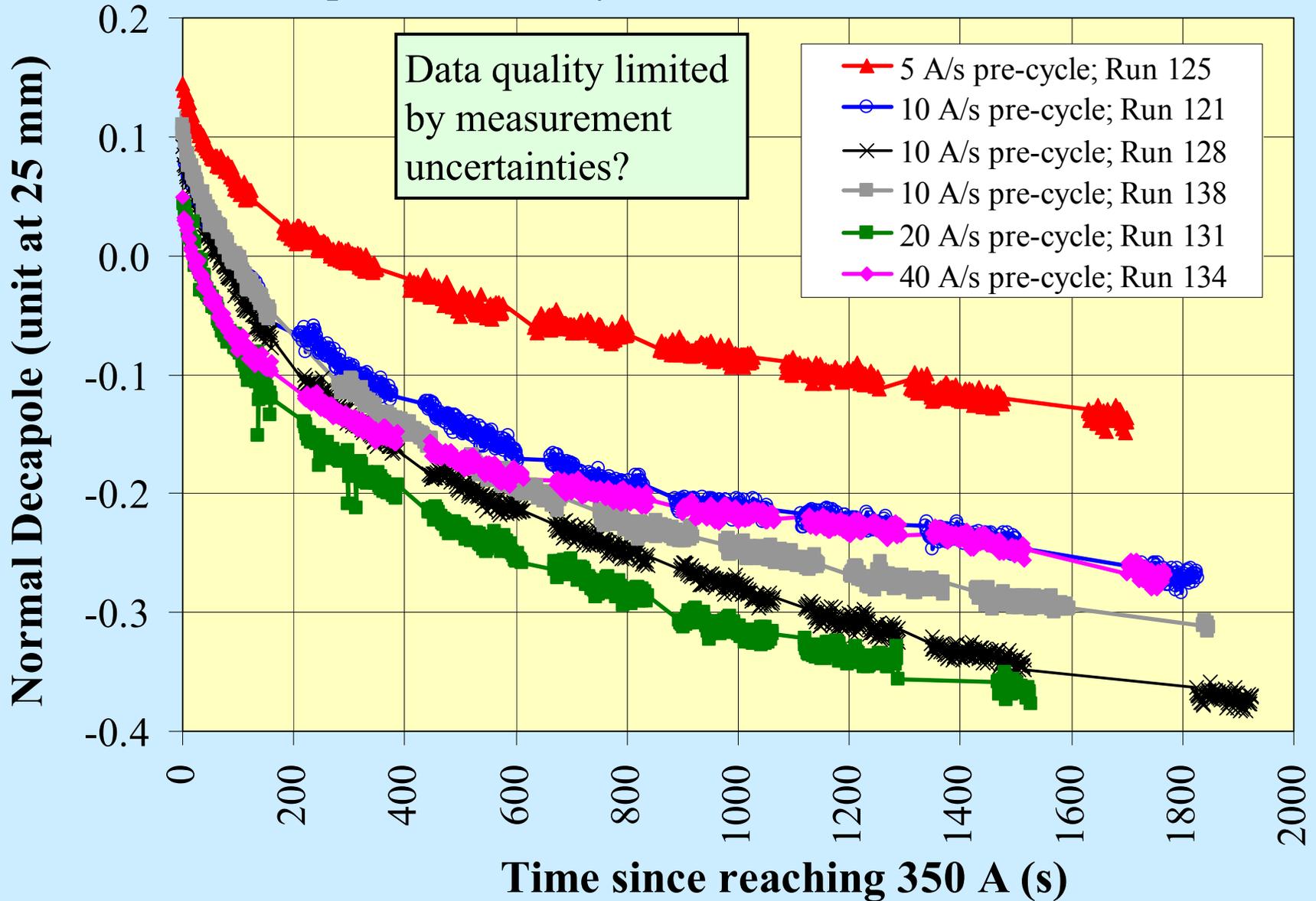
Time Decay Vs. Pre-Cycle Ramp Rate

Sextupole Time Decay at 350 A after 25 A to 350 A at 10 A/s



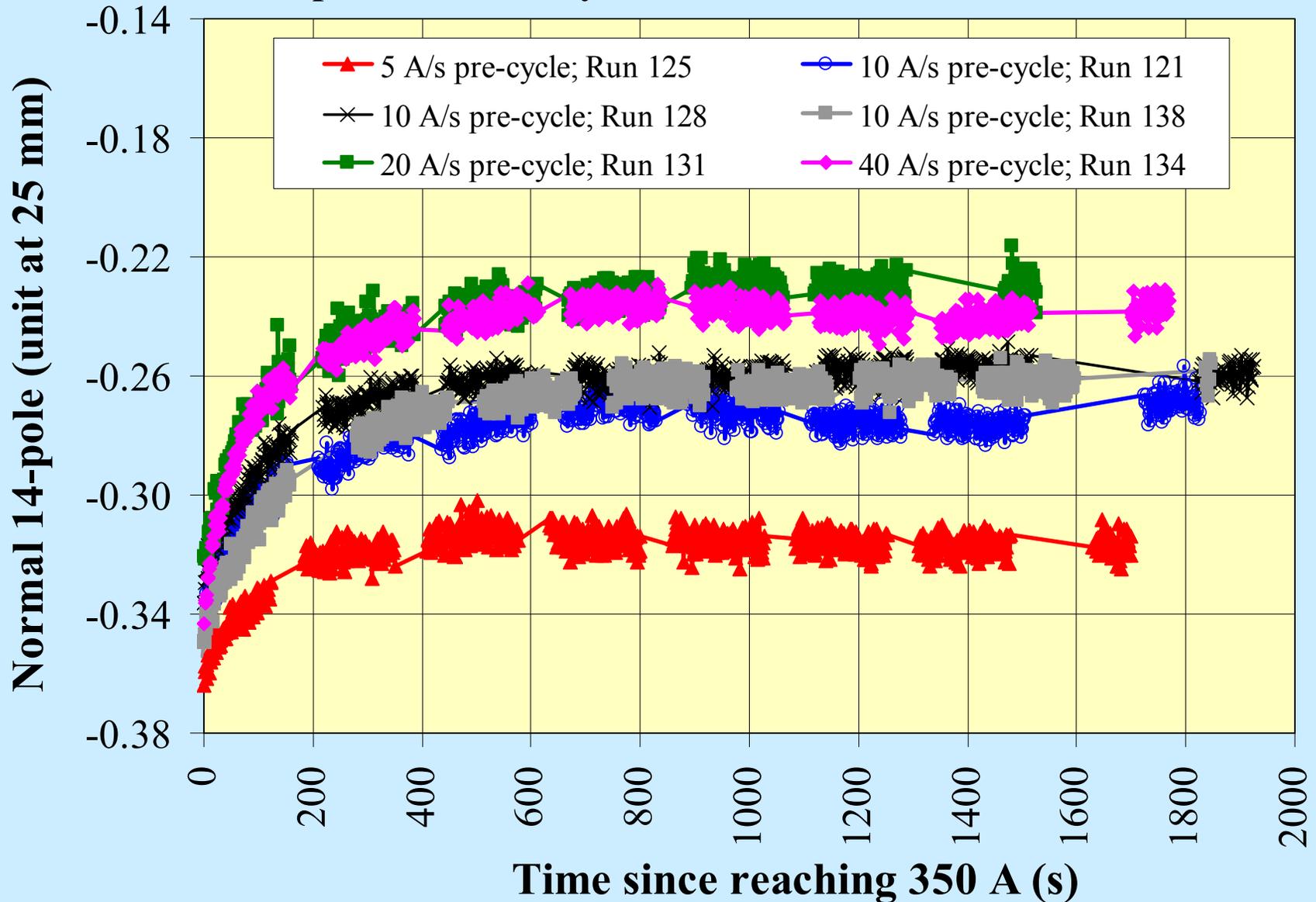
Time Decay Vs. Pre-Cycle Ramp Rate

Decapole Time Decay at 350 A after 25 A to 350 A at 10 A/s



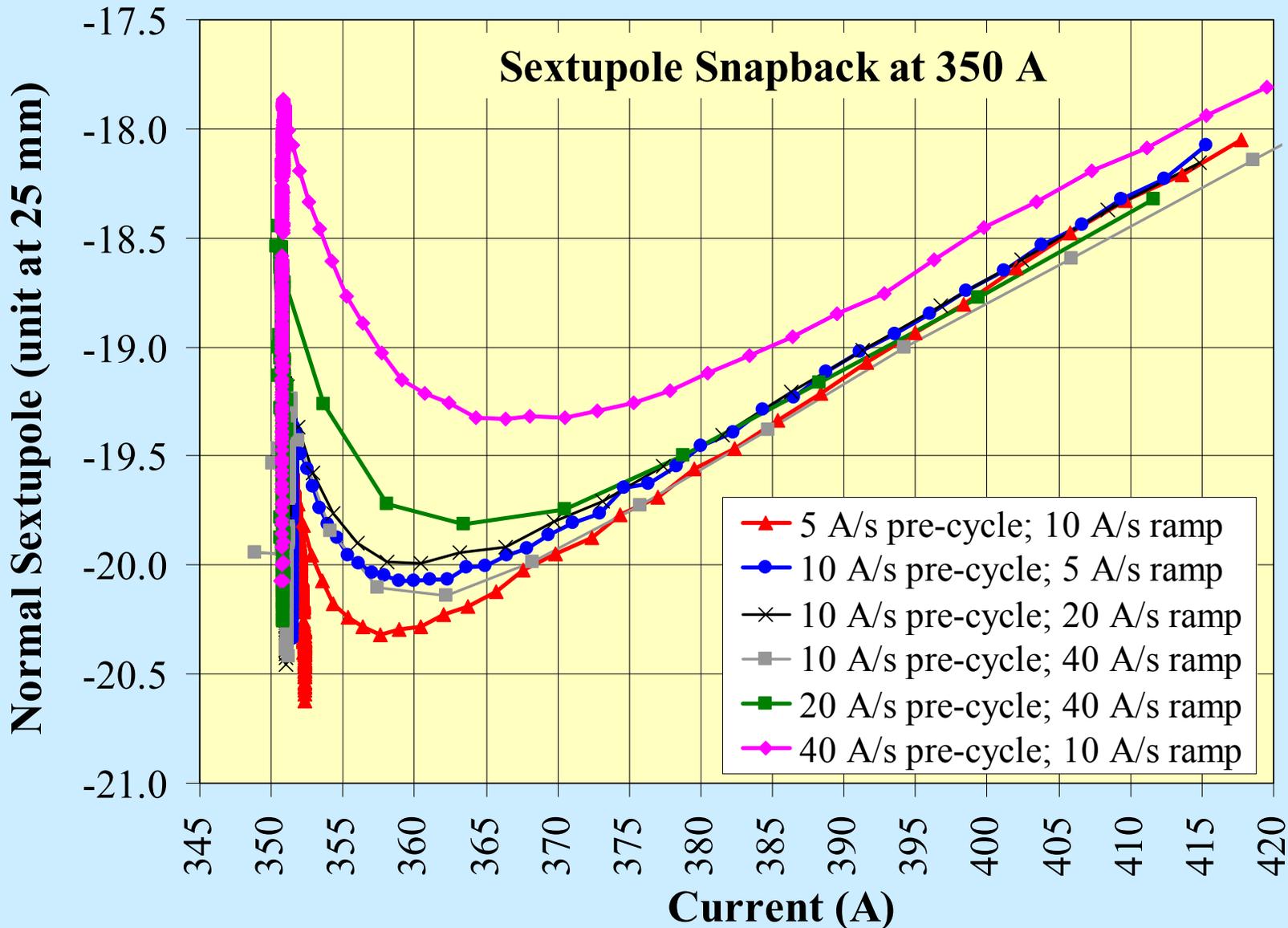
Time Decay Vs. Pre-Cycle Ramp Rate

14-pole Time Decay at 350 A after 25 A to 350 A at 10 A/s



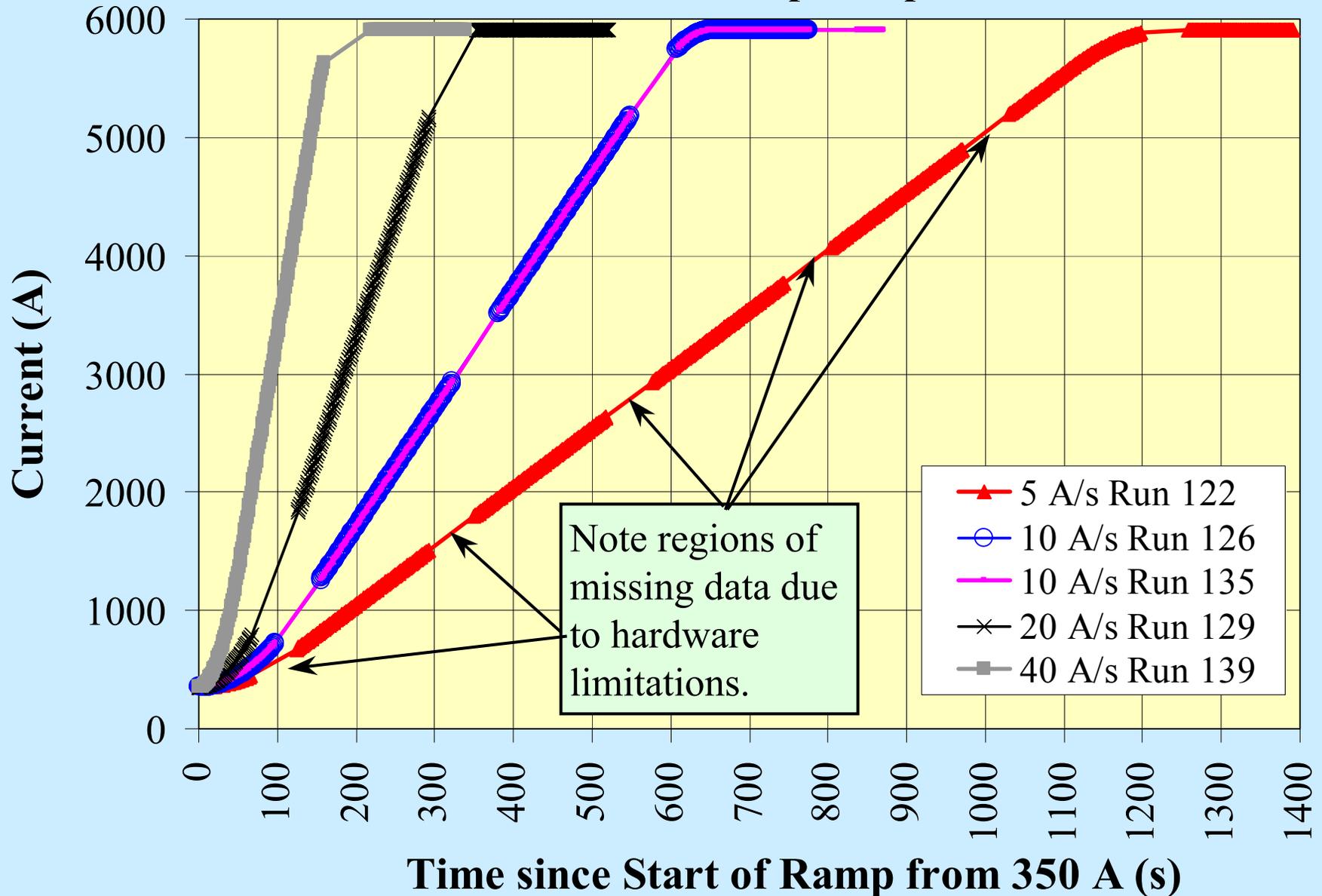
Snapback Vs. Pre-Cycle Ramp Rate

D3L102; 5900A cycle; Fast Meas.; Feb., 2005



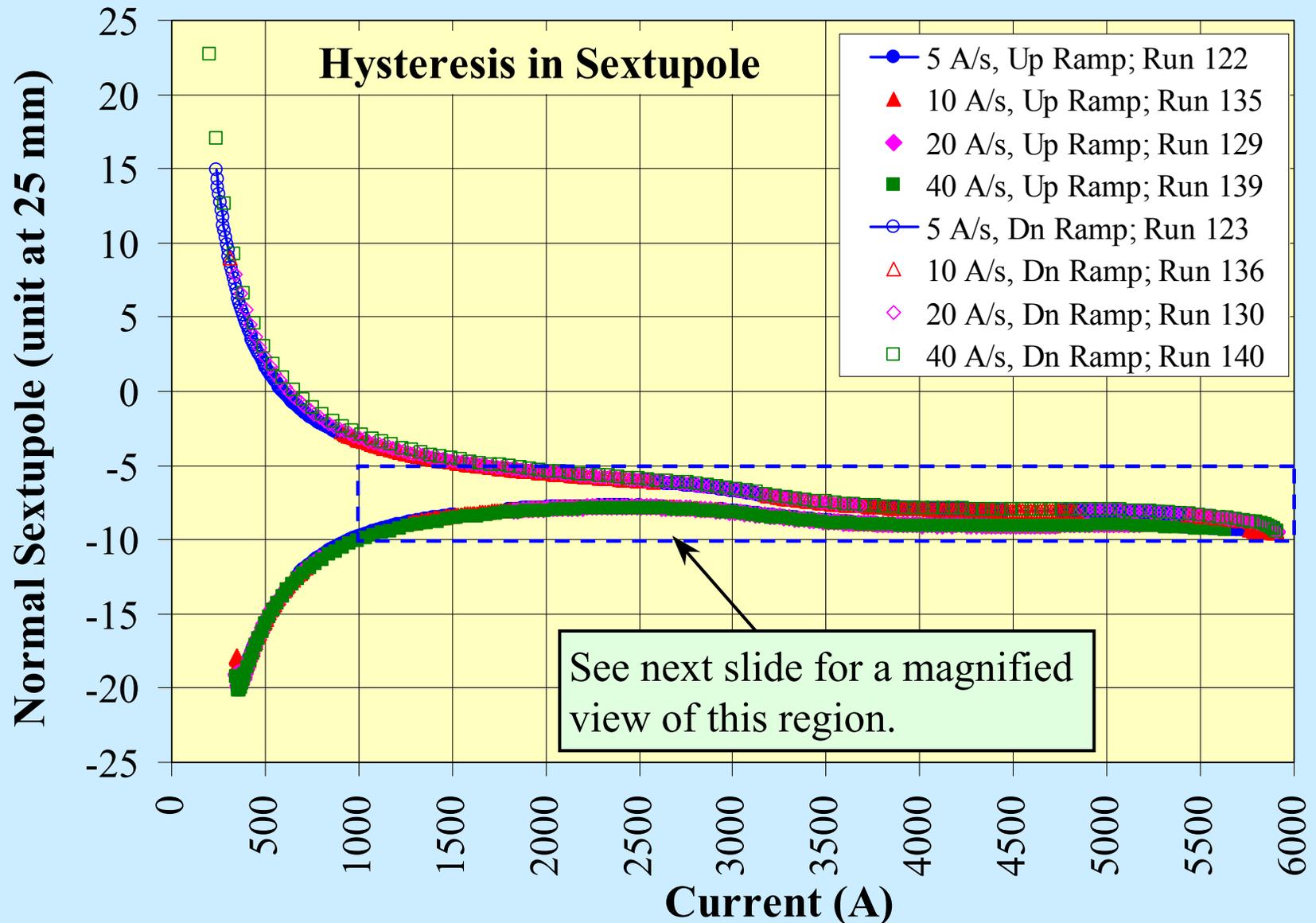
D3L102; 5900A cycle; Fast Meas.; Feb., 2005

Current Profiles on Up Ramp from 350 A



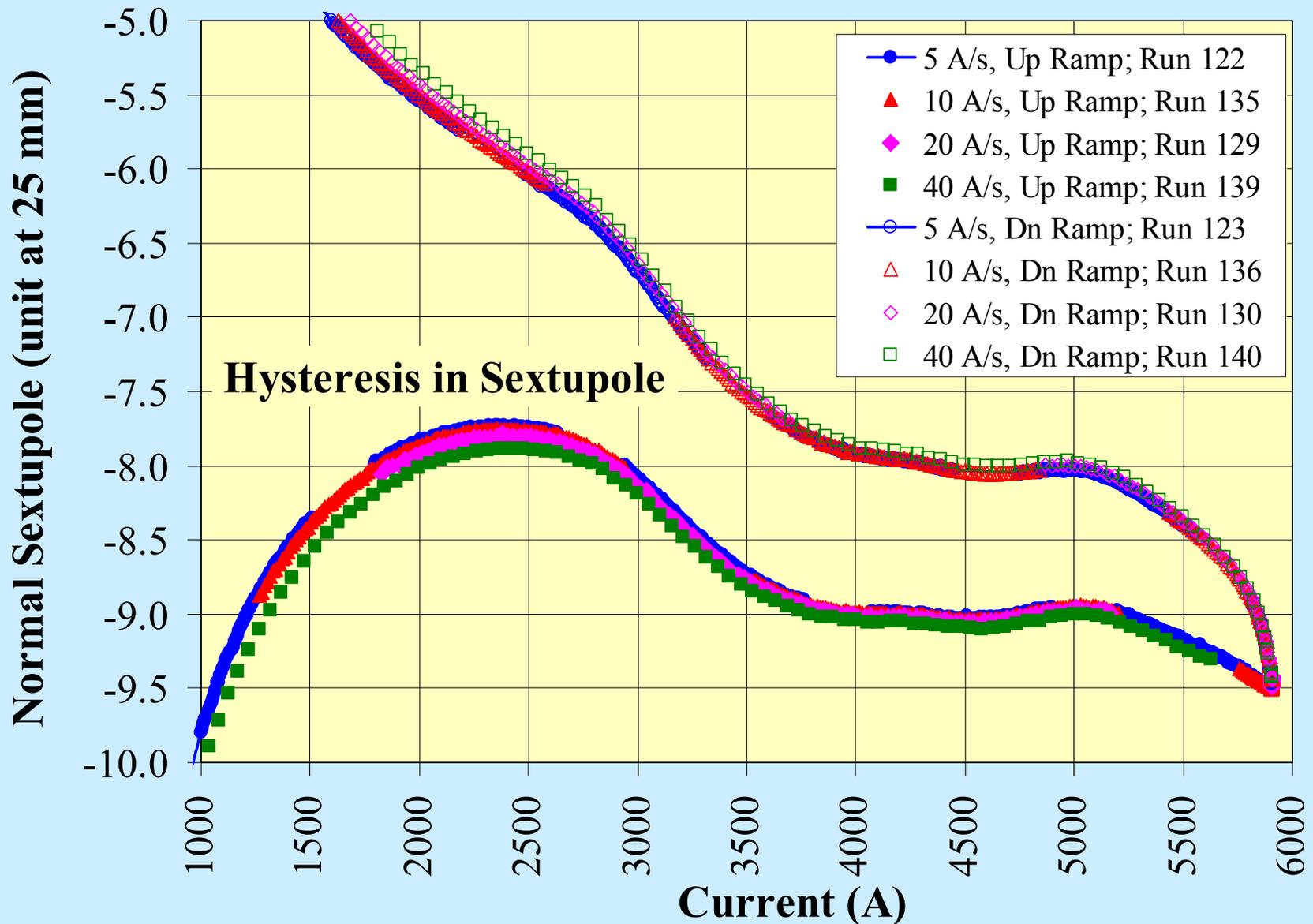
Harmonic Measurements During Ramping

D3L102; 5900A cycle; Fast Meas.; Feb., 2005



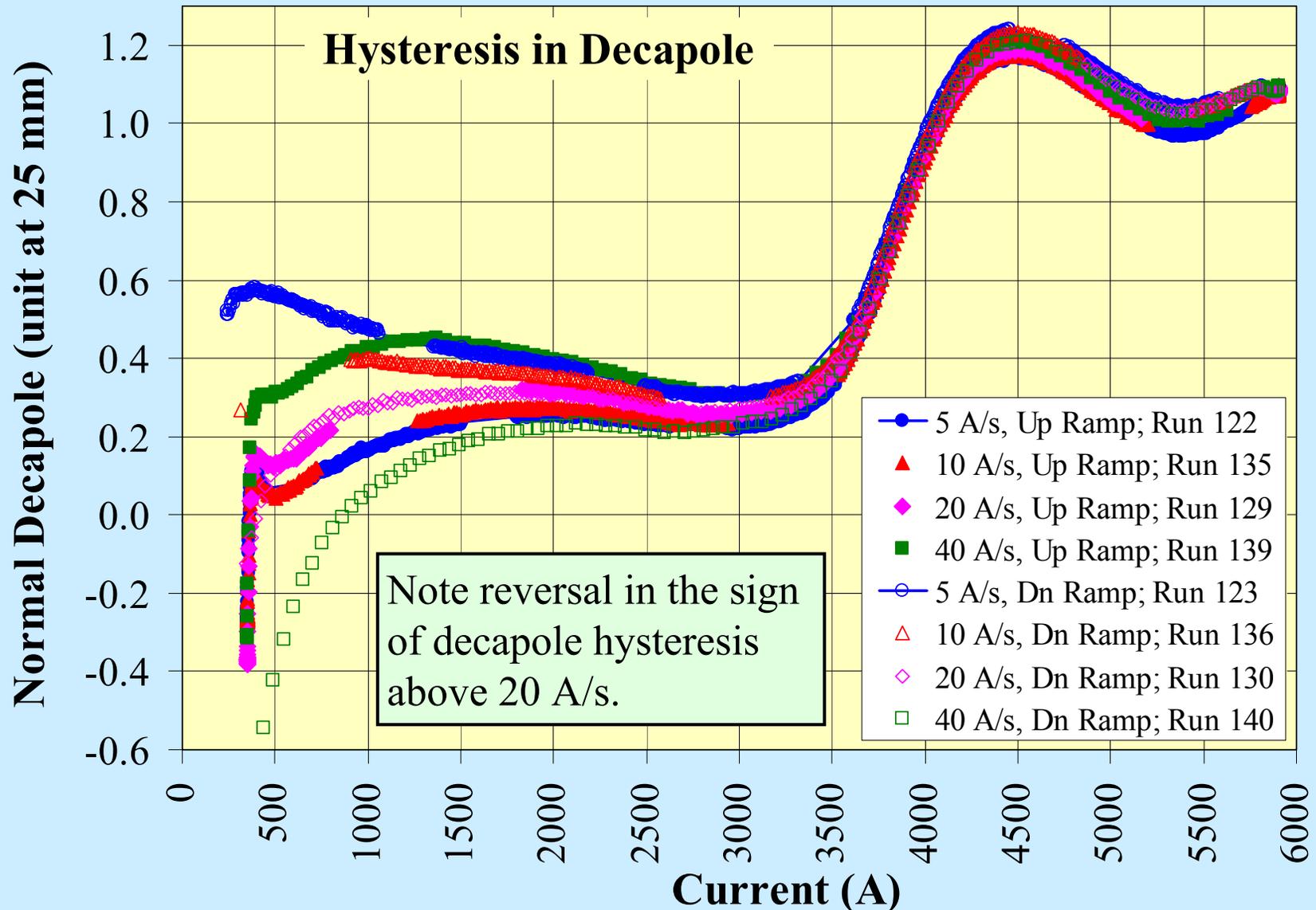
Harmonic Measurements During Ramping

D3L102; 5900A cycle; Fast Meas.; Feb., 2005



Harmonic Measurements During Ramping

D3L102; 5900A cycle; Fast Meas.; Feb., 2005



Harmonic Measurements During Ramping

D3L102; 5900A cycle; Fast Meas.; Feb., 2005

